POWER PLANT ENGINEERING

Established Over 32 Years

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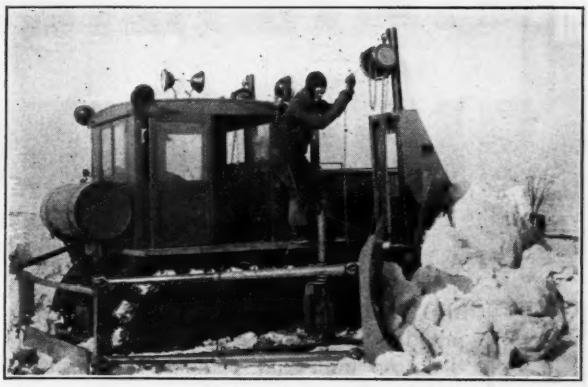


B-r-r-r-r! Look at This and Shiver!

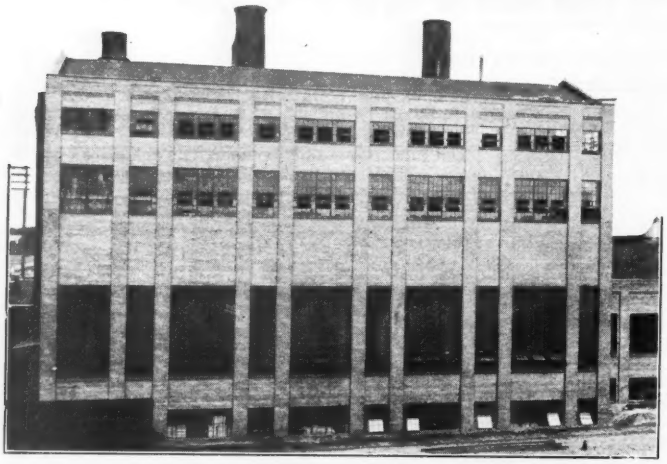
AS WE WRITE THIS, the mercury is slowly but steadily pushing its red tentacle up the tube—past 94 now and still going. Of course, we know it's not the heat; it's the—oh, well, we do get some relief, however, from looking at this picture of a tractor plow at work clearing roads in Minnesota with the temperature at 156 deg. Baumé or some such stupendous figure. Doesn't it send the cold shivers down your back just to look at it?

Time was when the rural dweller was snowbound in winter and the jingle of sleigh bells, the creaking of runners on crisp snow and the shouts of the drivers filled the air when the merry agronomists wanted to travel 5 mi. for a dance or a wedding. Nowadays, however, the farmer in winter rolls along in his flivver over the concrete road that has been cleared by one of the devices shown above. As noted by Tycos-Rochester, where this picture first appeared, we accept this change as a matter of course although we admit that there was considerably more romance coupled with the jingle of silvery sleigh bells and merry laughter than there is with this thing chug chugging through the snow.

This reminds us, incidentally, of the subject of ice, which, like snow, is another form of water—or is it snow that is a form of ice? It's too hot to worry about that now. All we care about is getting the ice. Great changes have also occurred in our methods of obtaining this boon to humanity; on page 889 of this issue you may read about the remodeling of an ice plant to fit the changing practices of modern refrigeration.

Whew! Writing about ice and snow with the thermometer at 94 is hot work! So we cast another glance at the picture and sigh with longing for a tall pitcher of ice cold—er—lemonade.

Paper Mill Plant Shows Central Station Influence



CONSOLIDATED WATER POWER & PAPER CO. AT WISCONSIN RAPIDS INSTALLS EXTRACTION TURBINE, 450-LB. BOILERS, DUAL FAN DRIVES AND BOTH AIR PREHEATERS AND ECONOMIZERS. BARK IS DRIED IN SPECIAL DRIER BY FLUE GAS AND IS BURNED ON STOKERS ALONE OR WITH COAL. HIGH STEAM PRESSURE GIVES INCREASED ECONOMY OF BY-PRODUCT POWER AND PLENTY OF PROCESS STEAM FROM EXTRACTION TURBINE. VERTICAL ARRANGEMENT OF EQUIPMENT IS OF INTEREST

FOLLOWING THE LEAD of engineering practices as carried out in the central station, the industrial plant has often been able to adapt many of these practices, with certain modifications, to its own conditions. In such cases, it is usually found that large reductions can be made in cost of steam and power, when their importance in the manufacturing process is considered. In paper mills, where costs of power and steam form comparatively large proportions of the cost of the product, many opportunities present themselves to take advantage of central station progressiveness in design. That this was apparent to the Consolidated Water Power & Paper Co. in erecting its new power plant at Wisconsin Rapids, Wis., is evidenced by the appearance and performance of the installation.

PLANT DESIGNED FOR 450-LB. STEAM PRESSURE

As the company's paper production increased, the expansion of the processes soon reached a point at which they were short of the necessary steam and there was not enough low-priced power to grind all the pulp. To meet these conditions, a new power plant was built. It was decided to generate steam at 425—450 lb. pressure and by use of an extraction turbine to secure by-product power, thus balancing the steam and power loads. It was figured that, using this higher pressure, the by-product power, as compared with that from steam at the former low pressure, would be increased from 1000 kw. to 4000 kw. and that this power would be produced at an expenditure of about 4000 B.t.u. per kw-hr.

Accordingly, the plant described here was designed on this basis by W. F. Thiele, chief engineer of the company, who also supervised its erection. In its arrangement of boiler house equipment, as shown in Fig. 5, its similarity to many central station boiler houses is striking. Its chief characteristic is the vertical arrangement of equipment in which, for the most part, the flow of gas is upward and the flow of heavier materials is downward.

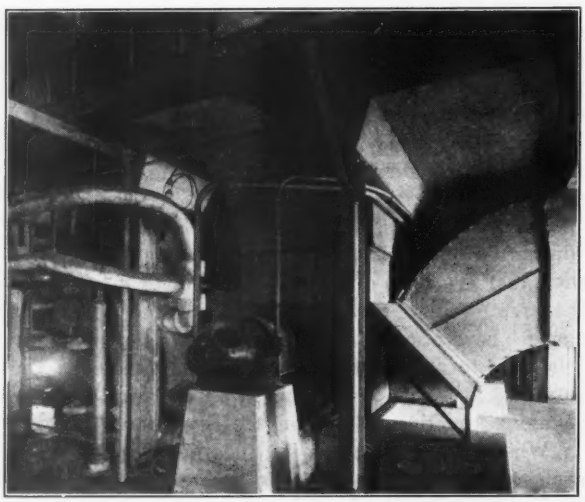


FIG. 1. FORCED DRAFT FANS WITH DUAL MOTOR DRIVE AND WATER ECONOMIZERS ON FLOOR ABOVE BOILERS

BARK AND COAL CAN BE BURNED SEPARATELY OR TOGETHER ON STOKERS

Coal burned on stokers forms the bulk of the fuel but, as large quantities of bark are by-products of the pulp-making process, provision was made for drying this bark and burning it on the stokers either alone or on top of the coal. Following another modern trend, most of the sheet metal work for air and gas ducts, hoppers and casings was fabricated in place by electric welding. Further similarities to central station practice are found in the use of both air preheaters and economizers and of forced and induced draft fans with dual motor drive.

Condenser water flows through the main unit condenser by gravity, under a head produced by the dam of a hydroelectric plant owned by the company on the Wisconsin River just above the mill. For this reason no condenser circulating pumps are installed.

These features, which will be discussed in more detail below, show the care that was taken to design a plant for the highest economy and best service. At the same time, while every feasible method of reducing

power and steam cost has been incorporated, the plant is not freakish but remains simple and convenient to operate.

Methods of operating the steam plant in conjunction with the hydraulic plant are of interest. The company has eleven water wheels furnishing mechanical power to pulp grinders and line shaft drive and two hydroelectric generating units. All these wheels are operated when there is enough water but when there is not enough water, a sufficient number of units is shut down so that the remaining units run at proper gate opening for maximum efficiency. The latter would include one of the hydroelectric units. For about one month each year, water conditions are such that the steam turbine is not operated at all; live steam from the boilers is passed through reducing valves to give the proper process steam pressure in each department.

Boiler Settings Designed for 200 Per Cent of Rating

Four boilers of the cross-drum water-tube type, each with 8190 sq. ft. of heating surface, are set as shown in Fig. 5. Boiler settings are designed for normal operation at about 200 per cent of rating; they are of solid refractory with no air or water cooling but they have rows of special arch tile set in them. Boiler tubes are set in two decks, as shown, with an interdeck convection superheater of 1360 sq. ft. surface in each unit. Steam is generated at 450 lb. per sq. in. gage pressure and the superheater is designed to give a total temperature of 700 deg. F. at 200 per cent of rating.

Underfeed stokers with grate area of 140 sq. ft. each are designed to operate at 200 per cent of rating continuously with combustion air at 250 deg., and at 300 per cent for two hours. They are driven by multiple-speed, 440-v., 3-phase, a. c. motors, manually controlled.

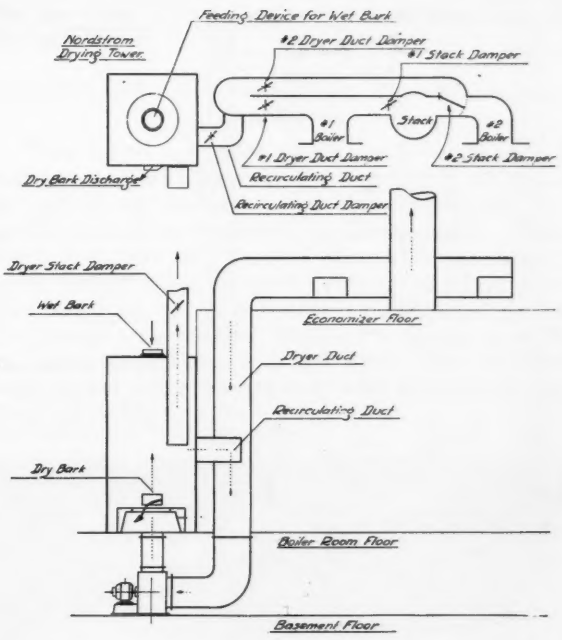


FIG. 2. LAYOUT OF DUCTS TAKING FLUE GAS TO BARK DRIER

Fuel, as stated above, consists mostly of coal, with bark from the wood mill as a secondary fuel. Coal comes to the plant from Green Bay in hopper bottom cars, which dump to a bucket elevator of 50 t. an hour capacity that deposits it on a belt conveyor running across an overhead coal bunker of 215 t. capacity. No crusher is installed at present but space is provided for

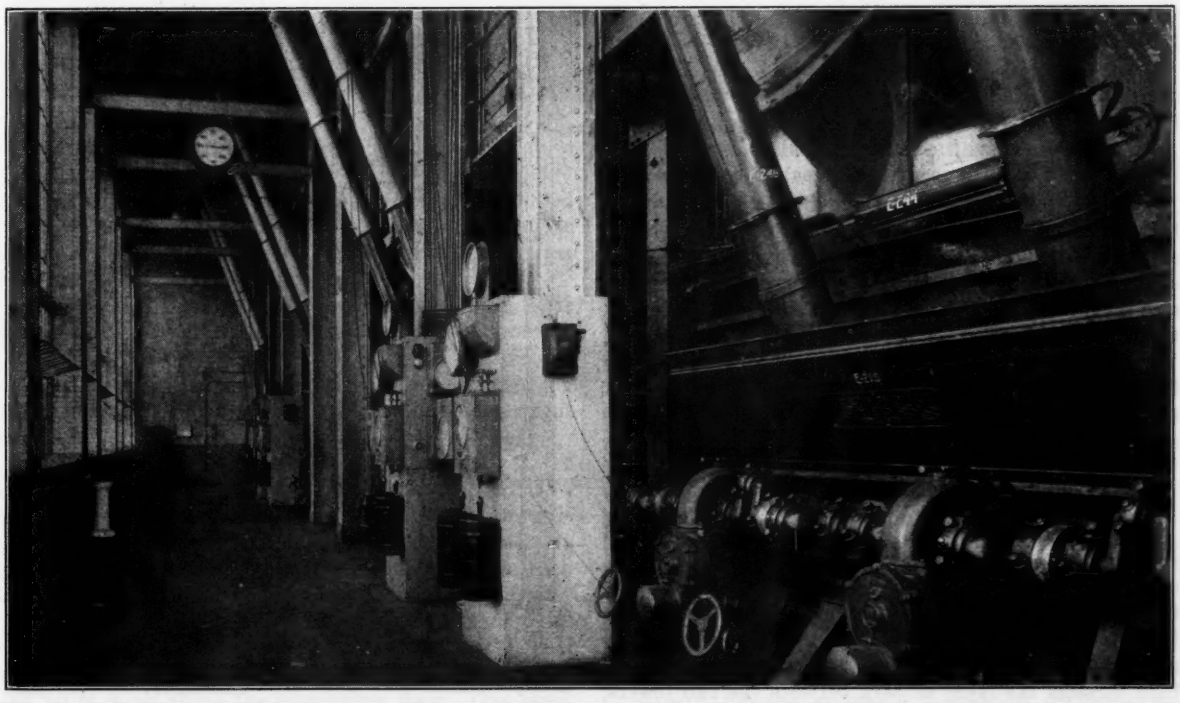


FIG. 3. ONE MAN OPERATES EACH PAIR OF 819-HP. BOILERS FROM THE CONTROL BOARDS. BARK BURNERS SHOWN JUST OVER STOKERS

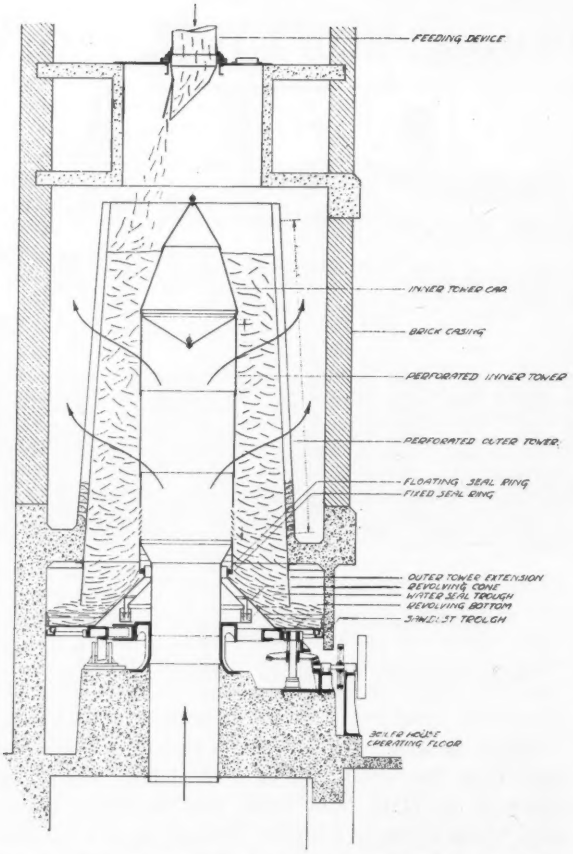


FIG. 4. FLUE GAS DRIES BARK FOR STOKERS IN THIS DEVICE

one. Coal is unloaded from this bunker by a 2000-lb. weigh larry running along a floor below the bunker; this floor seals off the bunker from the boiler room, preventing dust. The larry feeds coal to any one of four coal pockets just below the floor, Fig. 5, from which the coal is spouted to the stoker hoppers. Bunker and pockets are lined with concrete. Coal spouts are oscillated mechanically to secure even coal distribution.

Bark is prepared for burning in a special type of bark drying tower, using flue gas for drying. This is said to be the first installation of this bark dryer in this country; the Consolidated Water Power & Paper Co. also has the only installation of this bark drier in Canada, installed about the same time as the one at Wisconsin Rapids. This dryer has been used in Norway for several years. Figure 4 shows the construction of the dryer and Fig. 2 shows how it is connected. It is set on the firing floor in one corner of the boiler room.

Flue Gas from Two Boilers Dries Bark

Wet bark, brought on a conveyor from the wood room, feeds to the space between two perforated towers, one inside the other, Fig. 4; flue gas is discharged from two boilers into the inner tower. At the bottom of the inner tower is a water seal, so that the only way the flue gas can escape is through the tower perforations and then through the layer of bark between the two towers, thus drying the bark. The bottom of this layer rests on a revolving table which discharges the bark at one side, the whole being proportioned so that the rotation of the table causes the bark to pass slowly down between the inner and outer towers. Dried bark is discharged to a conveyor system that carries it up over the boilers to a conveyor running just above the level of the weigh larry, Fig. 5. Here the conveyor drops the bark into hoppers feeding chutes that run down to two burners set in the front wall of each furnace just above the stokers. From the burners, the larger pieces of bark can drop directly onto the stokers. These burners are of welded steel and are water-cooled where they enter the furnace. This entire bark drying and handling system has a capacity of 3 dry tons of bark an hour.

Flue gas for the dryers comes from boilers 1 and 2 of the battery, the ducts, stack connections and dampers being as shown in Fig. 2. When the dryer is not in use or is running light, flue gas from either boiler or both is discharged by the induced draft fan in the usual manner through the stack. By manipulation of the various dampers, it can be sent to the dryer, dis-

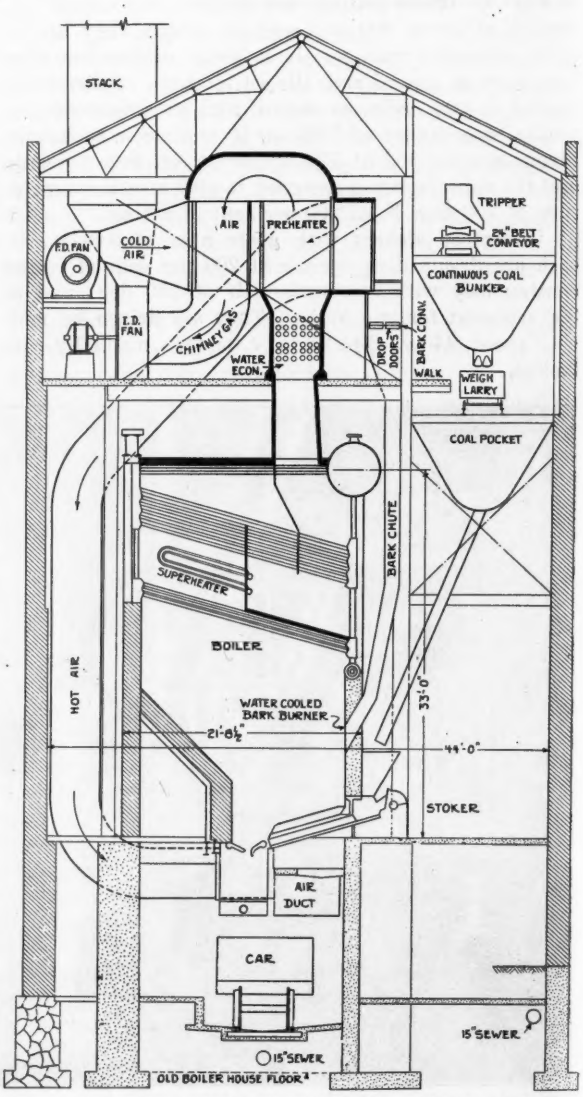


FIG. 5. CROSS-SECTION THROUGH BOILER HOUSE, SHOWING HIGH LAYOUT SIMILAR TO THAT OF MANY CENTRAL STATIONS

charging through the dryer stack. A recirculating arrangement is provided on the dryer for the flue gas, as shown.

Ash from the stokers drops to hoppers equipped with water quenchers and air-operated ash gates that discharge directly to gondola cars which take the ash away for use in filling streets. Boilers were set high above the grade line so that this arrangement could be used, thus effecting a large saving in cost of ash handling.

Feedwater Must Go Through Economizer, as There Is No Bypass

Flue gas leaving each boiler passes first through a steel tube economizer of 2016-sq. ft. heating surface. At 200 per cent of boiler rating, this is designed to take flue gas at 600 deg., discharging it at 425 deg., and to take feedwater at 210 deg. and send it to the boilers at 276 deg. Double feedwater piping system is installed but there is no bypass around the economizer. In other words, if feedwater is to get to the boiler at all, it must pass through the economizer.

From the economizer, flue gas passes to a tubular two-pass air preheater or air economizer, just above it, as shown. This heater reduces the gas temperature from 425 deg. to 250 deg., at the same time preheating the combustion air from 70 to 266 deg. at 200 per cent of rating.

This combustion air is taken from the top of the boiler house by a fan delivering a maximum of 29,000 c.f.m. at 8.25 in. water on each boiler, which forces it through the preheater and down through the ducts to the stoker air chamber, as shown. Flue gas from each boiler is drawn through economizer and air preheater by a fan of 50,000 c.f.m. maximum capacity at 6 in. water draft. This fan sends it, as shown, to the steel stacks, of which there are two, each 8 ft. in diameter and 50 ft. high above the economizer floor. One stack serves two boilers and, as previously explained, the stack for boilers 1 and 2 can be bypassed to send the flue gas from the induced draft fans of these units to the bark dryer.

Magnetic Control Governs Speed Changes on Dual Fan Drives

Each forced and induced draft fan is driven by two ball-bearing variable speed induction motors, as shown on the list of equipment, one large motor and one smaller one, direct-connected to the fan shaft. While one motor drives the fan, the other idles, a magnetic speed control being provided to change the load automatically from one to the other for varying demands. For example, the induced draft fan is driven by a 30-hp. motor for speeds up to 690 r.p.m., then the magnetic control shifts the load to a 75-hp. motor for speeds from 690 to 870 r.p.m.

FIG. 6. FROM THIS 5000-KW. TURBINE GENERATOR, STEAM IS EXTRACTED FOR PROCESS WORK AT 125 LB. AND 25 LB. CONDENSER AIR REMOVAL EQUIPMENT AT LEFT AND SWITCHBOARD AT RIGHT

Boiler feedwater consists of condensate from the condenser of the main turbine-generating unit, supplemented by treated makeup water. The latter, taken from the river, is heated and purified in a 6500-g.p.h. hot-flow, lime-and-soda softener. It then flows to a surge tank, mixes with the condensate and goes to the boiler feed pumps.

Two feed pumps are used; each is a 4-stage, 400-g.p.m. centrifugal unit designed to deliver against a head of 500 lb. One unit is driven by a 2200-v. synchronous motor, the other by a single-wheel steam turbine taking steam at 450 lb. throttle pressure and exhausting at 25 lb. gage to a process steam header, as will be explained later. Feedwater level in the boilers is controlled by automatic regulators.

This new plant stands on the site of an old boiler house, with the turbine room adjoining one end. The building is of brick and steel construction, with gypsum and felt roof.

Except for the automatic regulation of feedwater and the magnetic controls on the dual fan drives, opera-

tion of the boilers and stokers will be manual. Boilers are set singly, with individual control boards between each pair; one operator will handle two boilers. Steam-flow air-flow meters, indicating gages, Venturi meters to give a check on water flow and motor controls are grouped on the control boards; the entire system is flexible and compact.

Steam that goes all the way through the turbine is condensed by a 5500-sq. ft. surface condenser. This is a 2-pass unit, with two water boxes arranged so that one-half of the condenser can be cleaned at a time, while the other is operating. Circulating water is supplied to this condenser by gravity. The dam of the hydroelectric plant produces a head of 32 ft. and the

Equipment in New Power Plant of Consolidated Water Power & Paper Co.

General

Location.....Wisconsin Rapids, Wis.
Present Capacity.....5000 kw.
Designed by.W. F. Thiele, Chief Engineer
Service .....
Power and process steam to paper mill

Boilers and Stokers

Boilers.....Springfield Boiler Co.
Number 4
Type.....Cross-drum water-tube
Heating surface, each.....8190 sq. ft.
Working steam pressure.....
.....450 lb. per sq. in. gage
Working steam temperature.....
....700 deg. at 200 per cent of rating
Superheaters.....The Superheater Co.
Number 4
Type.....Elesco, interdeck
Surface, sq. ft.....1360
Superheat.....250 deg. at 200 per cent of rating, corresponding to total temperature of 700 deg.
Stokers...Westinghouse Elec. & Mfg. Co.
Number 4
Type.....7-retort, underfeed
Grate area, each.....140 sq. ft.
Capacity.....To give 200 per cent of rating continuously with air at 250 deg. F.; 300 per cent for 2 hr.
Drive.....Westinghouse 440-v., 3-phase, 60-cycle, multiple-speed motors
Bark Burners....Geo. B. Limbert & Co.
Number.....8 (2 per boiler)
Type.....Water-cooled, welded steel
Furnaces.....Bigelow-Liptak Corp.
Number 4
Type .....
Solid wall, refractory, with special tile
Economizers.....Foster Wheeler Corp.
Number 4
Type .....Steel tube
Heating surface, each.....2016 sq. ft.
Designed for flue gas temp., at 200 per cent rating..In, 600 deg.; out, 425 deg.
Designed for water temp.....
.....In, 210 deg.; out, 276 deg.
Air Preheaters....Foster Wheeler Corp.
Number 4
Type.....Tubular, 2-pass
Heating surface, sq. ft.....6160
Designed for gas temp. at 200 per cent of rating..In, 425 deg.; out, 250 deg.
Designed for air temp.....
.....In, 70 deg.; out, 266 deg.

Fuel and Ash Handling Equipment

Storage Bunkers and Pockets.....
.....Worden Allen Co.
Capacity .....215 t.
Coal Conveyors.....Link-Belt Co.
Type.....1 Peck carrier; 1 belt conveyor
Capacity.....50 t. an hr.
Drive.....10-hp. motor
Weigh Larry.....Link-Belt Co.
Capacity .....2000 lb.
Crusher.....Future installation
Oscillators, stoker spouts.....
.....Coal Spout Oscillator Co.
Bark Conveyors.....Link-Belt Co.
Type.....1 bucket, 1 belt
Ash Hoppers and Gates.....
.....Allen-Sherman-Hoff Co.
Type .....Air-operated cylinders; water quenchers

Bark Dryer.....
...Combustion Engineering Corp., Ltd.
Type .....Nordstrom
Capacity.....3 dry t. per hr.
Drive.....15-hp. motor

Draft Equipment

Induced Draft Fans...Buffalo Forge Co.
Number .....4 (1 per boiler)
Type .....Turbo-conoidal, single-width, double-inlet
Capacity, each, maximum.....
.....50,000 c.f.m. at 6 in. H_2O
Drive.....Duplex, ball-bearing, variable speed ind. motors
Speeds to 690 r.p.m.....One 30-hp. motor
Speeds 690 to 870 r.p.m..One 75-hp. motor
Automatic magnetic speed control....
.....Cutler-Hammer Mfg. Co.
Forced Draft Fans...Buffalo Forge Co.
Number .....4 (1 per boiler)
Type .....No. 7
Capacity, each, maximum.....
.....29,000 c.f.m. at 8.25 in. H_2O
Drive..... Duplex, ball-bearing, variable speed induction motors
For speeds 450 to 870 r.p.m.....
.....One, 25-hp. motor
For speeds 870 to 1165 r.p.m.....
.....One 60-hp. motor
Automatic mag. speed control.....
.....Cutler-Hammer Mfg. Co.
Steel Stacks.....Worden Allen Co.
Number 2
Type .....Welded
Height above econ. floor.....50 ft.
Diameter .....8 ft.
Breechings, air and gas ducts.....
.....Cons. W. P. & P. Co.
Type .....All steel plate, electrically welded in place by company

Boiler Accessories and Mechanical Equipment

Auxiliary Driving Motors.....
.....All Allis-Chalmers Mfg. Co. except as otherwise noted
Type.....440-v., 3-phase, 60-cycle
Boiler Meters, temperature and draft gages, indicators and recorders....
.....Bailey Meter Co.
Venturi Meters..Builders Iron Foundry
Water Columns.....Stets Co.
Indicating Steam Gages.....
.....Ashton Valve Co.
Feedwater Level Regulators.....
.....Copes, Northern Equipment Co.
Mercon regulators used with Copes f. w. l. reg.; also const. red. press. regulator on softener.....
.....Mercon Regulator Co.
Soot Blowers.....
.....Diamond Power Specialty Corp.
Valves:
Safety .....Consolidated Ashcroft Hancock Co., Inc.
Stop and check.....Crane Co.
Blowoff.....Yarnall-Waring Co.
Drainage Control.....
.....(Copes) Northern Equipment Co.
Piping and Valves.....
...Pittsburgh Piping & Equipment Co.
Piping and Duct Insulation.....
.....Johns-Manville Corp.
Furnace Observation Doors.....
.....Springfield Boiler Co.
Gratings .....Kedrick Co.
Stairs .....Home-made
Elevator .....Otis Elevator Co.
Lubricating Oil Filters.....
.....General Electric Co.

Feedwater Pumps and Treating Equipment

Heater-Softener .....
.....International Filter Co.
Number 1
Capacity .....6500 gal. an hr.
Type.....Hot-flow-lime-and-soda process
Boiler Feed Pumps...Ingersoll-Rand Co.
Number .....
2 (1 motor-driven, 1 turbine-driven)
Type .....4-stage Cameron centrifugal
Capacity, each.....
.....400 g.p.m. at 1150-ft. head
Speed .....1800 r.p.m.
Motor drive for one.....
.....Electric Machy. Mfg. Co.
Type..2200-v., 200-hp. synchronous motor
Turbine drive for one.B. F. Sturtevant Co.
Type .....Single wheel, 200 hp.
Steam pressure .....450 lb. at throttle, 25 lb. exhaust to 25-lb. process and f. w. heat system
Pump governors .....
.....Edward Valve & Mfg. Co.

Turbine Generator and Auxiliaries

Turbine Generator..General Electric Co.
Number 1
Type.....Extraction, 2 points
Capacity.....6250-kv.a., 80 per cent p. f., 2300-v., 3-phase, 60-cycle
Steam pressure, throttle.....
....425 lb. gage, 700 deg. total temp.
Extraction pressures.....125 lb., 25 lb.
Exciter .....Direct-connected
Condenser.Westinghouse Elec. & Mfg Co.
Number 1
Surface, sq. ft.....5500
Type.....Two-pass, divided water boxes
Condenser circulation.....
.....Gravity, no pumps installed
Air Removal Equipment.....
.....Westinghouse Elec. & Mfg. Co.
Condensate Pumps.....
.....Westinghouse Elec. & Mfg. Co.
Number 1
Type .....Centrifugal
Capacity.....150 g.p.m.; 70-ft. head
Drive.....Westinghouse 440-v. motor
Exciter.....Allis-Chalmers Mfg. Co.
Number 1
Type .....Motor-generator set from old power house
Capacity .....150-kw., 125-v., d. c. generator driven by 2300-v. motor
Switchboard, meters, switches.....
.....General Electric Co.
Transformers.....General Electric Co.
Number 6
Type .....Water-cooled; 2300/440 v.
Capacity .....
....Three 1000-kv.a.; three 250-kv.a.
Miscellaneous Switches for auxiliaries .....Square D, Westinghouse, Cutler-Hammer
Air Compressor.....Ingersoll-Rand Co.
Number 2
Capacity.....528 and 368 c.f.m. free air
Drive .....Motor

By-product power is generated by a turbine-generator of 6250-kv.a. capacity, 0.8 p. f., which replaces two smaller units. This makes 3-phase, 60-cycle power at 2300 v. The turbine, Fig. 6, is a double-extraction unit, steam being extracted from it at 125 lb. gage and at 25 lb. gage. Throttle pressure is 425 lb. gage, 700 deg. total temperature. The turbine generator has a direct connected exciter.

condenser is set so that normally it gets the benefit of 14 ft. of this head.

Air removal equipment is set on the turbine room operating floor, following the latest practice, for easy access and observation by the turbine operator. Excitation is taken either from a direct-connected exciter or from a separate motor-generator set. Generator air-cooling is of the open circuit type.

Extraction steam at 125 lb. serves a piping system for the paper making processes and is mostly used in the pulp digesters. Another steam system at 25 lb. pressure takes the 25-lb. extraction steam from the main unit and the exhaust from the turbine-driven boiler feed pump. This steam is used mostly for paper drying, but it is also used for heating in the water softener.

For large motors, power is sent to the mill direct at 2300 v. For smaller motors, it is stepped down to 440 v. by two banks of water-cooled transformers. All auxiliary motors in the power plant are 440-v. units with the exception of the 2300-v. synchronous motor driving one of the feed pumps and the 2300-v. motor of a motor-generator set.

Preparation of Boiler for Winter Load

CORRECTING KNOWN FAULTS IN THE DESIGN OF FURNACES, HUNTING FOR AND REPAIRING DEFECTS DUE TO SERVICE. BY JOHN NOVOTNY*

PROBABLY THE most disagreeable and often the most neglected work around a plant is the boiler and furnace maintenance. This is due in a measure to the lack of thorough inspection and systematic record charts for repair work. Many times necessary repairs are neglected because the necessary materials and tools are not on hand to begin repair work on boilers and furnaces. After a boiler is off the line and can be spared for repairs, it should be inspected internally and externally and cleaned thoroughly. Usually after boiler tubes are turbined, much of the excess soot and external dust is thrown down, then a thorough cleaning and inspection of the refractory and furnace settings can be made.

WHAT IS WRONG AND WHERE

Of course the furnace walls look pretty bad; that is to be expected. The boiler tops should be cleaned off with a vacuum cleaner or the heavy dust removed by hand, then compressed air or even steam should be used. This will clearly show up the cracks, while sweeping merely covers them and they are left unnoticed. One should go inside and check up the cracks in each pass, check up the baffle walls, soot blower and soot-blower supports, check up the clearances for the necessary outlets through the setting and see if there is any settling of the side walls, check up the clearance between the tubes and side walls, see if the supporting steel is in order, especially between the walls (See Fig. 1), at the dusting doors and bridge walls.

Wear and tear on a boiler furnace is greatest in the area above the grates in the first pass. Especially is this so since 200 and 300 per cent ratings are common. Furnace costs are considerable under these conditions.

Why is there so much furnace repair and what are some of the remedies?

1. Many of the furnaces are not properly designed.

2. Furnaces are ruined because of carelessness of operators or because the furnaces are not equipped with proper draft gages and furnace regulators, or properly installed controls for operating the furnaces and many times the equipment is not kept in order.

3. Inspection and record charts are too frequently lacking. If records are kept of the material used in each boiler and some effort is made to study the causes and kinds of material used, an improvement can generally be made the next time.

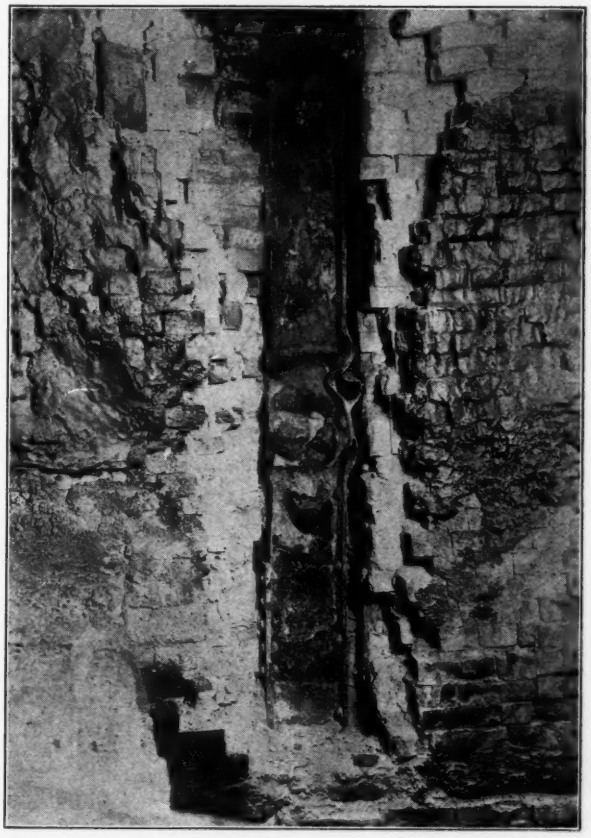


FIG. 1. DEFECTIVE SUPPORTING COLUMN BETWEEN BOILERS IN BATTERY DISCOVERED DURING INSPECTION

4. When furnaces are let down for short periods, for cleaning, many times clinkers are knocked off and much damage is done. These patches should be given special attention and should be well coated with good refractory material.

5. Arches and side walls are often taken down carelessly and much of the old brick is wasted which could be used over again either in the same wall or by crushing brick bats into ganister. Then by adding to it high grade cements, much of this well seasoned refractory material could be used in patching by hand or be used in a cement gun. Frequently large arch blocks that are partly broken can be used to an advantage in the construction of the next bridge wall; in doing so, it

*Chief Operating Engineer, University of Wisconsin.

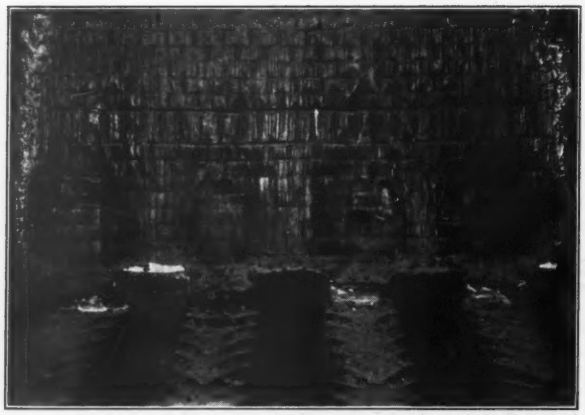


FIG. 2. REFRACTORY CONDITION AFTER TWO WEEKS OPERATION

FIG. 4. CONDITION OF WALL SHOWN IN FIG. 3 AFTER FOUR WEEKS' SERVICE

will save the cost of many fire brick, cement, and much labor in the course of a year.

Results of Poor Design

Many a furnace has been properly constructed according to the design, subsequently to find that the overheating of the first pass was due to improper baffling, causing the bottling up of the heat in the first pass. By rearranging the baffling, the furnace temperature was reduced considerably and the refractory material of even second grade would last longer than the expensive materials tried out with the first arrangement.

Life of refractory materials can be lengthened a great deal by the use of air-cooled walls, cold water backs, perforated brick, modern furnace equipment and the proper kind of materials. Many side walls and bridge walls can be protected against clinker formation by the use of small steam jets through which exhaust steam from the stoker engine is passed. Many times damage is done in furnaces because no allowance is made for expansion and contraction. Sometimes steam jets are used to advantage to cause turbulence in the furnace. Proper location of the steam jets is necessary, as otherwise they may cause the heat to be concentrated in one place, resulting in slagging and rapid burning out of the walls and grates.

Figure 2 shows how badly the front walls of a furnace was burned in two weeks' time, demonstrating that there was a lack of air above the tuyeres of an underfeed stoker. To correct this, air was provided over the tuyeres, being supplied through openings between bricks, as shown in Fig. 3. The front wall was repaired by using a cement gun to apply a mixture of ganister, fire clay and thermolith high temperature cement.

Further operation of the furnace resulted in the condition shown in Fig. 4. Evidently the temperature in the furnace was still high and some of the plastic cement ran down and filled the openings between the bricks. It proved, however, that where the air came through the burning of the brick was reduced to the minimum. The furnace was run at 200 per cent for four weeks with 0.10 in. draft over the fire.

With the idea of shedding the running slag off the front wall, a 2-in. ledge was made above the staggered brick. This resulted in an improvement, as will be noted in Fig. 5 over Fig. 4—operating the furnace under the same conditions.

Having proved the advantage of having air admitted through the furnace wall, the staggered brick was removed and ventilating blocks were installed as shown in Fig. 6.

Figure 7 shows the side walls of 516-hp. boiler 5-retort underfeed stoker after 1 yr. operation. These side walls were in good condition except for some clinker above side wall tuyeres. This clinker condition

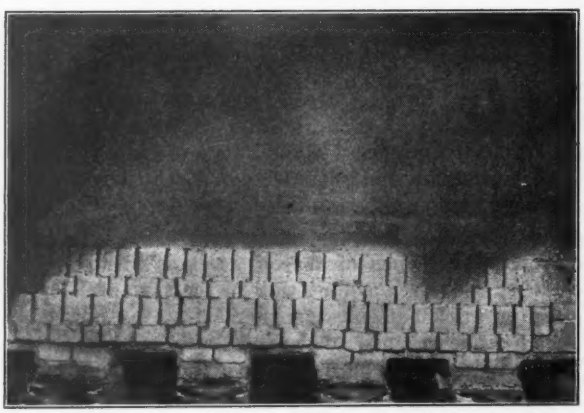


FIG. 3. FRONT WALL PROVIDED WITH AIR PORTS BETWEEN BRICKS

FIG. 5. RESULTS SHOWN HERE WERE OBTAINED BY PLACING 2-IN. LEDGE OVER AIR PORTS

was reduced by installing small jets of steam under the side wall tuyeres.

In Fig. 8 is shown the bridge wall of same combustion chamber after 1 yr. run. The heavy clinkers forming on the tubes above bridge wall resulted from using Indiana screening of high dust content. Draft over the fire was between 0.05 in. and 0.10 in. This clinker trouble seems to be considerably less when using Illinois Franklin Co. coal or West Kentucky coal.

Bottling Effect Caused by Clinker

Many times it is found that burning of a low grade of coal containing much foreign matter and debris causes clinkers to form on the first row of tubes to such an extent that a bottled up condition exists in the furnace. If this condition occurs for but a brief period of time, it causes heavy clinkers to form and slagging of the furnace. Clean passageways, properly placed baffles, ample combustion space, tight wall settings, the proper thickness of the fuel bed and proper draft over the fire will effect savings in the boiler and furnace maintenance and increase the efficiency of the unit as well.

After the furnace walls are repaired, the working clearances of the stoker should be checked, the grates, tuyeres, dumping grates and driving mechanism repaired, the connecting links and pins, the ashpit and furnace doors should be repaired.

Next the outside walls should be examined and every small crack closed. Many times the boiler walls and settings are in good condition but considerable infiltration occurs around the cleaning doors and door frames and especially at the boiler connection to the breeching.

Checking Up on Instrument Readings

Occasionally false readings are obtained in the flue gas recorder. The temperature may be recording low because the pyrometer is not in the proper place or an air leak is of such extent as to cause a current of cold air to be mixed with the flue gases and lower the temperature at the pyrometer whereas the actual temperature of the waste gases is several hundred degrees higher than it should be. High flue gas temperature usually indicates broken baffles or heavily coated heating surfaces.

Next in order is repairing the dampers and breeching, cleaning out the passageway to the chimney and removing the accumulation of soot and dust at the foot of the stack. All iron work should be scraped and painted or some anticorrosive materials used at regular periods, particularly on the equipment that is idle during the summer or located in damp places.

Following the cleaning of the boilers, needed repairs should be made on auxiliary equipment, packing valve stems, replacing gaskets, repairing covering, cleaning water cooling devices and their connections, checking up on safety valves and automatic check valves, blowoff valves, traps, filters and other boiler room devices.

After the boilers are cleaned and repaired, coal and ash handling equipment should likewise be checked and repaired carefully, the supports of the piping system examined, a close check-up of boiler feed equipment is important. All the recording instruments should be cleaned and checked.

Finally an effort should be made to clean the building, brightening up the dark places and to have everything in its place. Storage spaces provided for repair parts, supplies, oils, etc., should be in a neat condition. That "cleanliness is next to godliness" will not be realized unless everybody at all times strives to do his part to maintain order.

Then you will realize the satisfaction of knowing that your plant is prepared to take up the increasing load and you are sure that all of the equipment is in

FIG. 6. PATENTED VENTILATING BLOCKS ARE MORE SATISFACTORY THAN STAGGERED FIRE BRICKS

FIG. 7. GOOD CONDITION OF SIDE WALLS ATTRIBUTED TO TUYERES

FIG. 8. BOILER TUBES COATED WITH CLINKER WHEN USING LOW GRADE SCREENINGS

first class condition and all the avoidable hazards and burdens are removed. The operators can then direct their energies to obtaining the best possible results without being distracted by numerous defects and dangerous conditions of equipment.

In steam turbine practice, H. L. Guy gave the opinion before the Institution of Civil Engineers that at present 350 lb. pressure is as high as should be used for 10,000-kw. plants or under; 550 lb. as the limit for 20,000-kw. plants. He stated that the present tendency is against reheating by flue gases at least for pressures below 800 lb. but reheating by steam is attracting attention.

Industrial Plant Changes to Pulverized Fuel

CAPACITY AND EFFICIENCY INCREASED BY CHANGE IN FUEL HANDLING AND BURNING AND IN FURNACE CONSTRUCTION AT MORLEY BUTTON PLANT

STEAM IS PRODUCED, at the plant of the Morley Button Mfg. Co., Portsmouth, N. H., exclusively for process work and heating. The demand is fairly constant, requiring from 400 to 530 hp. during the summer months and from 625 to 750 hp. during the winter. Minimum demand usually occurs during 5 of each 24 hr. and maximum demand during 10 of each 24 hr.

Operation is continuous from 8 p. m. on Sunday to 7 a. m. the following Sunday. Steam is required for drying in the paper board mill and for 187 baking ovens used for baking the finishes on the various types of buttons. A considerable amount of heat, ranging in temperature from 180 to 300 deg. F. and requiring a steam pressure of 100 lb. at the boilers is needed for the baking process and this must be maintained unfailingly for 24 hr. a day 6 days a week.

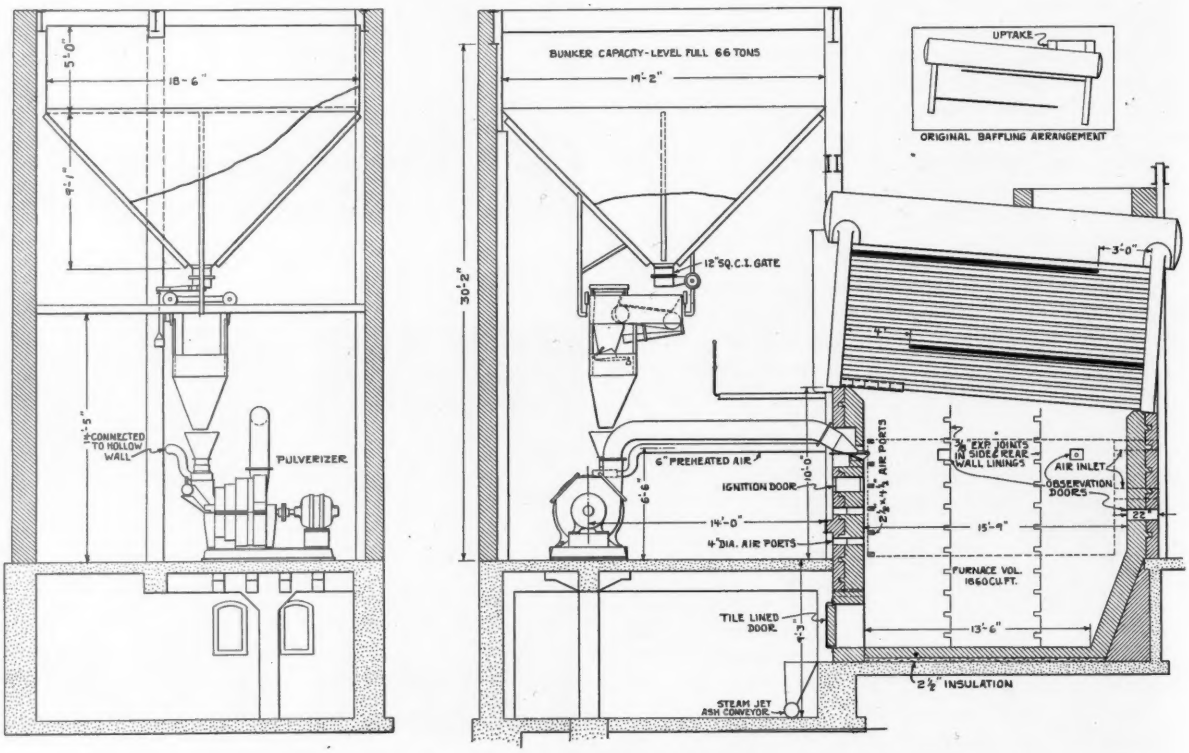


FIG. 1. PULVERIZED COAL ARRANGEMENT PROVIDES CONVENIENT HANDLING AND BURNING PROCESS

ORIGINAL EQUIPMENT INADEQUATE

For several years, steam was generated in four 150-hp. hand-fired, water-tube boilers. When more steam was required for the growing plant, a 400-hp. Heine two-drum, w. t. boiler was installed which was set 10 ft. above the floor line. This was intended to be fired by means of an automatic stoker but, due to the World War, high prices made such equipment inadvisable and the boiler was hand-fired; but labor cost at the wage scale then current was considerable and, as demand for steam had increased beyond what the equipment could meet under hand-fired operation, it was decided to install a coal pulverizer and make the necessary changes in the furnace.

In the original setting, the tubes were 14 high and the baffles arranged as shown in the sketch inserted in Fig. 1, the lower baffle being on the 5th row of tubes with a 4-ft. pass at the back and the upper baffle on the top row with a 3-ft. pass at the front. This was changed as shown in the layout below the sketch, Fig. 1, by reversing the baffling.

With the original arrangement of baffles, the smoke issuing from the stack was dense and the stack became foul; ash fused continually in the bottom of the combustion chamber, making conditions for operation in periods exceeding a week in length, impossible; one day's time was required to cool the boiler sufficiently to enable getting inside to break off fused slag and remove it; average evaporation was 10.7 lb. water from and at 212 deg. per lb. of dry coal and the firebed was unstable below 100 per cent rating.

After changing the baffles by making the gas openings at opposite ends from the original, the following improvements resulted: The stack became clear except

RESULT OF TWO TESTS TO DETERMINE PERCENTAGE OF FUEL IN GRADED DEGREES OF FINENESS

Resting on mesh of screen						Passing through	Coal pulverized net t.
Mesh of screen	48	65	100	150	200	200	
Coal in percent	0.0252	0.0763	0.1002	0.1225	0.2262	0.4485	2660
Coal " "	0.0104	0.0442	0.0583	0.0729	0.1440	0.6700	520

for an occasional light haze; fusing of ash in the bottom of the combustion chamber was eliminated; after minor adjustments were made, the average evaporation increased to 11 lb. steam from and at 212 deg. per pound of dry coal and the firebed became stable down to 50 per cent rating. The CO_2 meter also registered from 13 to 14 per cent.

Before the change was made to pulverized fuel operation, the boiler was supported on a concrete mat 6 ft. below the floor line. This part was excavated and refractory walls designed by Erie City Iron Works were installed.

New River coal containing from 3½ to 6 per cent of moisture and having a heating value of 14,400 B.t.u. is burned. Coal is received in cars on an overhead track whence it is dumped into a 400-t. coal pocket, adjacent to the boiler house. From here the coal is elevated by a Jeffrey apron-feed conveyor to an 18 by 18-in., Jeffrey, 30-t., single-roll crusher which is operated by a 10-hp. General Electric motor, in a manner shown in Fig. 2. After reduction by the crusher to size so that 100 per cent will go through a 1¾-in. ring, while 98 per cent will go through a 1½-in. ring, the fuel is passed over two 60-ft. Barber-Greene portable belt conveyors, connected in series and operated by a single 5-hp. General Electric motor.

Metallic Substances Magnetically Removed

Replacement of the head pulley of the conveyor by a Magnetic Separator Co. pulley was made in order to remove metallic substances as shown in Fig. 3. At this point, the coal drops through a chute to a 30-t. Jeffrey elevator which is operated by a 3-hp. General Electric motor and discharges into a 66-t. steel bunker

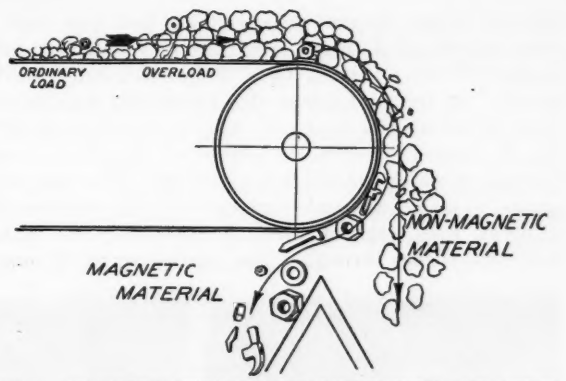


FIG. 3. MAGNETIC PULLEY SEPARATES IRON AND STEEL OBJECTS FROM FUEL

supported from the building walls and located in front of and above the boiler and pulverizer.

Coal feeds by gravity into a 200-lb. Richardson automatic scale, which is operated by a 1/5-hp. Emerson motor, thence discharged into a hopper over the pulverizer feed-table, as shown in Fig. 4. The scale is supported on rails, the normal position being in line with the boiler. When desired, the gate on the bottom of the bunker can be closed and the scale moved to one side.

Rate of Weighing Follows Demand

Weighing is regulated so that the rate at which coal is fed to the pulverizer is the same as that required to supply the furnace properly. This is accomplished by manipulation of the scale hopper-door, which automatically regulates the operation of the scale. If the hopper, below the scale and above the pulverizer, becomes filled, the scale hopper-door is held open and the scale becomes non-operative. When the coal is withdrawn by the pulverizer, the hopper-door is again free to close and the scale operates until coal backs up in the hopper. The capacity of the scale is 6 t. an hr., 200 lb. being weighed at a time.

From the hopper above the feed table, which is operated by a ¼-hp., d.c., variable-speed, Ohio motor,

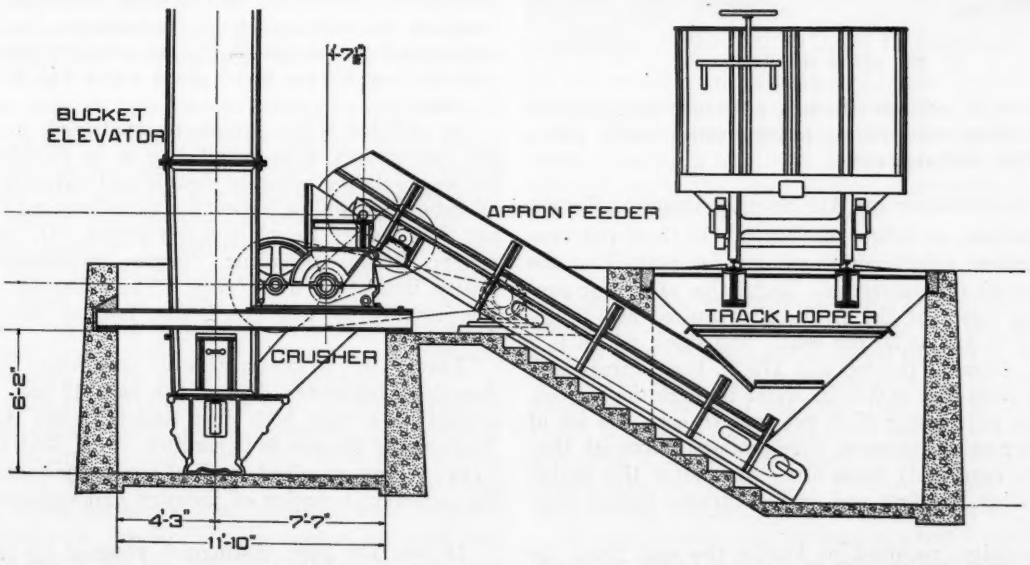


FIG. 2. COAL IS PASSED MECHANICALLY FROM CAR THROUGH CRUSHER TO OVERHEAD BUNKER

the coal passes through an adjustable feed gate onto a rotating feed table, thence to an Erie City unit type pulverizer, which is driven by a 40-hp. General Electric motor. As the coal leaves the feed-table, it is mixed with air which has been preheated to from 230 to 450 deg. F., depending upon the pulverizer adjustments and the rate at which the boiler is operating. The coal then passes, in stages, through three pulverizing chambers of different sizes, each of which is equipped with swing hammers, thence through a fan member to the furnace,

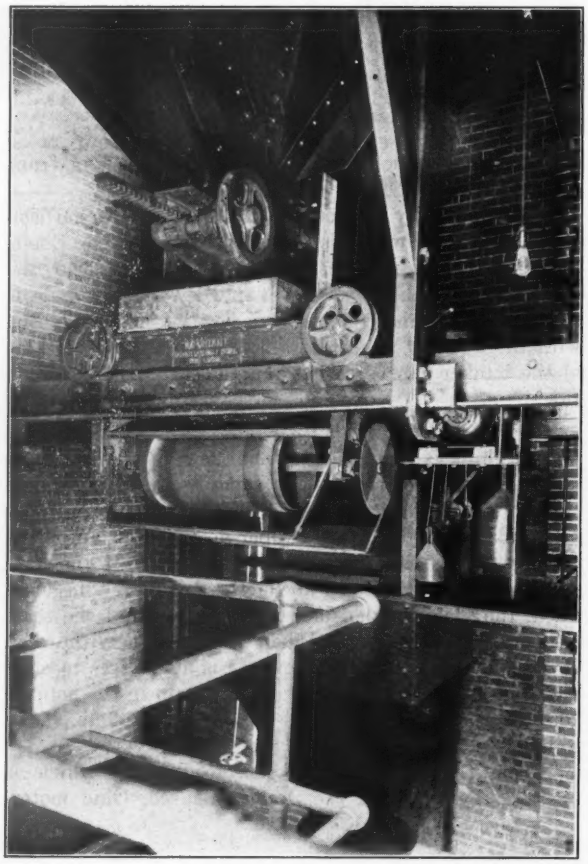


FIG. 4. WEIGHING OF COAL IS REGULATED ACCORDING TO RATE OF FIRING

into which it is blown through a 16-in. steel pipe and an Erie City water-cooled prong burner which has a 4 by 36-in. discharge outlet.

Close Adjustment of Air Supply Reduces Excess

Adjustable air inlets, just beyond the third pulverizing chamber, admit additional air for propelling the coal through the pulverizer. Regulation of the air supply is so fine that the excess air required can be reduced to as low as 30 per cent. The stack, which is 9 ft. 6 in. diam. at the top and 175 ft. high, furnishes a draft of from 0.05 to 0.15 in. water through the fire box.

After pulverizing 2730 net tons of coal, the set of pulverizer swing-hammers were replaced, although they were not completely worn out. Also, after this period of operation, the first and second furnace linings were replaced.

Electricity, required to handle the coal from the coal pocket to the bunker, amounted to 1.8 kw-hr. per t. and from the bunker to the boiler, 16.8 kw-hr. per t., making a total of 18.6 kw-hr. per t. Forty per cent of the entire amount of air required is used to blow the coal into the furnace, the rest being admitted into the furnace through hollow air spaces in the side walls and air ports in the front.

Ash is removed daily from the ashpit by hoeing it into a hopper whence it is delivered to an 8-in. United steam-jet, ash conveyor which elevates it 14 ft. and projects it 22 ft. horizontally, discharging it through a box, which contains a sprinkler nozzle, into an ash compartment 11 ft. wide by 15 ft. long and 10 ft. high, which is provided with a 30-in. vent and has a capacity sufficient for a 3-mo. run. It was found that the ash conveyor operated best with a steam pressure of from 90 to 100 lb.

New Arrangement Accomplishes Improvements

Operation of the boiler has been accomplished at from 200 to 900 b.hp. but it has been found advisable

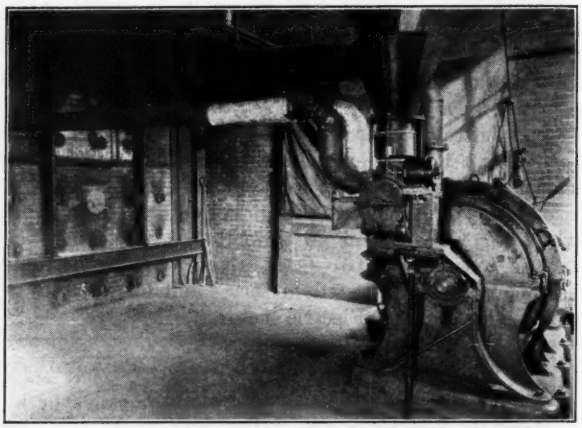


FIG. 5. THREE STAGE PULVERIZER REDUCES FUEL TO ALMOST GAS-LIKE FINENESS

to run it at 300 b.hp. or over because, below this rate of operation, the tubes slag and choke rapidly. Besides increase in convenience of operation, reduction in fuel handling and elimination of dense smoke, the rate of evaporation was increased 2¼ per cent over that of the original four 150-hp. boiler plant which was 8.5 lb. per lb. coal.

In addition to the equipment mentioned, the following instruments were installed so as to provide means for accumulating accurate records and reducing cost of operation: Republic indicating, recording and integrating flow meter; Republic motor-driven CO_2 recording meter; Bristol recording flue-gas thermometer and Bailey indicating draft gage. The plant as changed was installed by Wheelock-Bogue, Inc., of Boston.

Important standardization activities in many American industries during the past 12 mo. are described in a year book just issued by the American Engineering Standards Committee, 29 W. 39th St., New York; 49 new standards and 40 new projects are listed for numerous branches of industry and engineering.

If you are poor, distinguish yourself by your virtues; if rich, by your good deeds.—Joubert.

Deconcentrating Treatment of Boiler Water

IMPURITIES IN FEEDWATER ACCUMULATE IN BOILER, CAUSING TROUBLES WHICH MAY BE PREVENTED BY CONTINUOUS BLOWDOWN. BY H. L. GRIFFIN

ONE OF the prime requisites of high efficiency and economical boiler operation is feedwater of good quality. This attainment without the use of mechanical or chemical means is practically impossible, due to the fact that all natural waters contain more or less impurities in the form of soluble matter, insoluble or suspended matter or both. Water containing these impurities is fed to the boiler and evaporated into steam leaving behind all the impurities. As this evaporation process continues, the impurities in the boiler accumulate until the water becomes highly concentrated. These concentrated impurities act in various ways detrimental to boiler operation by causing priming, foaming, dirty steam, scale, corrosion and caustic embrittlement.

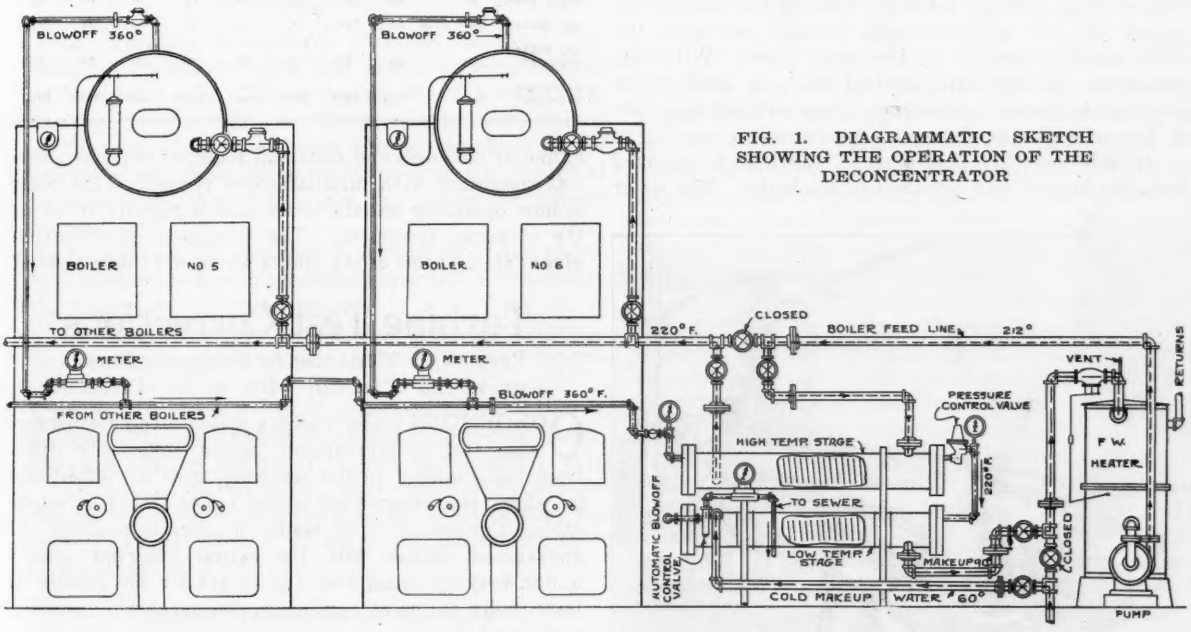


FIG. 1. DIAGRAMMATIC SKETCH SHOWING THE OPERATION OF THE DECONCENTRATOR

TREATING BY THE DECONCENTRATING METHOD

Most of the troubles caused by impure water are due to the fact that impurities are allowed to accumulate in the boiler. To overcome this trouble, some means must be provided to keep the concentration of impurities in the boiler down to a predetermined minimum at all times. This can be accomplished by the continuous blowing down of the concentrated impurities in the boiler and replacing this water with fresh feedwater containing a relatively small amount of impurities. This is known as the deconcentrating method.

For years partial elimination of boiler water troubles has been satisfactorily and successfully accomplished by periodically blowing down the impurities in the boiler. The complete elimination of all boiler troubles by continuous blowdown has, however, been economically prohibitive, due to the great cost of the heat that would be lost if the hot blowdown was piped direct to the sewer. Another obstacle in the way of continuous blowdown has been the lack of a suitable control device which would correctly proportion the amount of water fed to the boiler to that removed.

To obtain the benefits of continuous blowdown with no loss of heat and at the same time correctly proportion the blowoff water to the water being fed, a deconcentrator can be used. The sketch and explanation given here applies to a deconcentrator suitable for an average size industrial power plant.

As indicated in the illustration, the deconcentrator has two stages, a high-temperature stage and a low-temperature stage, each consisting of two or more shells containing a nest of small tubes. As the troublesome impurities are more concentrated at the boiling surface in the steam drum than elsewhere, the impure water outlet pipe to the deconcentrator is connected to the steam drum on a level with the bottom of a gage glass, this location of the outlet making it impossible to drain the boiler water through the pipe.

OPERATION OF THE DECONCENTRATOR

Usually the feedwater line is allowed to remain in use as before, except that it is cut and two tees with a valve between them are installed to provide a bypass connection to the high-temperature stage of the deconcentrator. The cold make-up line to the feedwater heater is likewise cut and two tees and a valve installed, providing a bypass connection to the low-temperature stage of the deconcentrator. If there are any hot water returns, they are fed to the heater without any change.

It will be noted that the impure water is drawn from the boiler near the steaming surface and flows through

a small pipe to the deconcentrator, passing through the nest of tubes in the high-temperature stage, where it is cooled by the incoming boiler feedwater, say from 350 deg. to about 212 deg. F. The flow continues into the low-temperature stage where the outgoing blowoff water is cooled by the incoming make-up water from about 212 deg. to a lower temperature, say 65 deg., at which a control valve is set and will pass it at this temperature to the sewer. Meters are installed to show how much water is being exchanged.

Tracing the piping, it will be seen that the cold make-up water passes to the low-temperature stage where it receives a preliminary heating from the outgoing boiler water. Admission from this stage to the heater is regulated by the usual heater control valve.

From the feedwater heater, all of the boiler feed passes through the high-temperature stage of the deconcentrator, picking up some heat in the process although the rise in temperature is small, owing to the much greater quantity of incoming water. With this equipment an automatic control valve is used which controls the blowoff according to temperature and rate of flow of make-up, degree of concentration, etc.

In this way, practically all of the heat is removed from the blowoff and returned to the boiler. The water

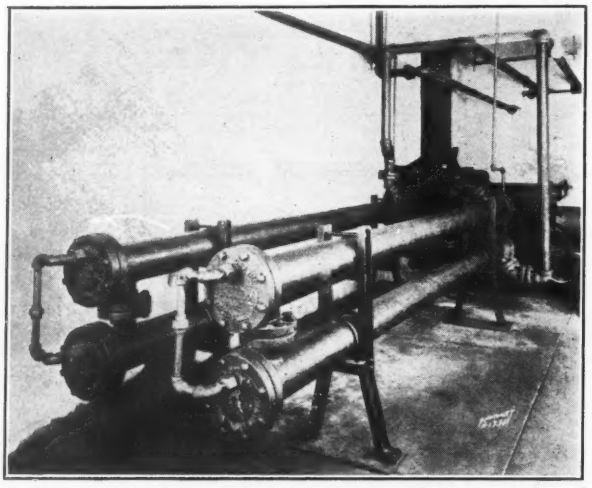


FIG. 2. INSTALLATION OF A DECONCENTRATOR IN AN INDUSTRIAL PLANT

is blown down only at such times as water is being fed to the boiler. The control valve is set so that no blowoff water can go to the sewer unless extraction of heat has lowered its temperature to some cool predetermined point.

Results with the Deconcentrator

Deconcentration can be carried to any extent desired but experience has shown that an exchange of 5 per cent of water fed to the boiler generally will produce the desired results. On the foregoing basis, the cost of deconcentrating has been placed at 2c per day for each 1000 sq. ft. of boiler heating surface.

Recently several deconcentrator installations were investigated with the view of comparing boiler water troubles before and after this system was installed. It was found that formerly all plants had been having more or less trouble with priming, scale, dirty steam, corrosion, etc. These troubles prompted the installation of the deconcentrator in each case. After they had been installed, boiler water troubles were practically eliminated. The corrosion, priming, etc., in zeolite plants was completely eliminated. Plants formerly using chemicals now use little or no treatment.

Most of the plants had water of 20 to 40 grains per gallon hardness. One plant had 200 to 400 grains per gallon of hardness and salts and required extreme chemical treatment with unsatisfactory results. This plant is now operating satisfactorily and is rapidly reducing the chemical treatment. The tabulated questionnaire gives data on some of the plants which were investigated.

QUESTIONNAIRE ON USE OF DECONCENTRATOR

Plant No.	1	2	3	4	5	6	7	8	9
Feedwater Gal.10 Hr.?	16,250	28,750	12,750	23,000	11,500	9,000	12,000	14,700	58,500
Blow-Down Gal.10 Hr.?	1,500	2,200	800	1,300	2,190	1,000	1,400	1,600	5,000
Chemical Treatment?	3 lb.	10 lb.	Zeolite	2 lb.	Zeolite	Zeolite	Zeolite	92 lb.	No
Any Priming?	No	No	No	No	No	No	No	No	No
Dirty Steam?	No	No	No	No	No	No	No	No	No
Any Scale?	Soft Film	No	Trace	No	No	No	No	No	Trace
Any Other Trouble?	No	No	No	No	No	No	No	No	No
Attention Required?	None	None	None	None	None	None	None	None	None

Turbine Test Corrections

Effects of Variation of Pressure; Superheat and Vacuum. By A. G. Powell

CONDITIONS under which a steam turbine consumption test is carried out almost invariably differ from those quoted in the manufacturers' specifications, to which the guaranteed steam consumption is applicable. Corrections to be made, in order to compare the guaranteed figures with the actual observed results under varying conditions (or to render the results of tests under different conditions comparable), are often a cause of doubt.

Reasons for Corrections

Always, the correction to be applied is the resultant of variation in two factors: *a*, available heat content of the steam; *b*, turbine efficiency, due to operation under conditions other than those for which it was designed.

Of the two, *a* is the more important, *b* altering only in a small degree according to the type and design of the turbine. The efficiency correction cannot well be calculated but is largely based upon extensive experience with turbines operated under varied conditions.

For any test figures, the correction to be applied is the sum of total corrections for variation of pressure, of superheat, and of vacuum.

By "total correction" is meant the sum of the correction for heat content and that for efficiency.

Effect of Pressure Variation

1. Correction to be made for pressure depends entirely upon whether the variation is before the stop-valve, or before the first stage nozzles. In the case of a turbine operating under constant load, raising the steam

*From Electrical Times, London, Eng.

pressure would cause the governor valve to close slightly, the pressure before the nozzles being little altered. The only result would be that the steam would be throttled to a greater extent than formerly, with net result that the steam consumption would be improved by the small amount corresponding to the additional superheat due to the greater degree of throttling. This actual improvement is about 0.5 per cent for every 10 per cent increase in pressure.

On the other hand, if the pressure before the nozzles is raised, the applicable correction is much higher and can be assumed to be:

For high-pressure turbines, consumption improved 1½ per cent; for low-pressure turbines, consumption improved 4 per cent for each 10 per cent increase in pressure.

Superheat Effect

2. Variation-of-superheat effect on the steam consumption is greater than that shown by consideration of heat value only. This is because the efficiency of the blading changes with each change of superheat, as long as the exhaust is wet, hence the actual effect of the change of superheat decreases as the degree of superheat increases; i.e., the effect is less, the nearer the exhaust becomes dry.

Increase of the available heat content of the steam, as a percentage due to increased superheat is practically uniform within the usual range.

Total correction for superheat is 1 per cent improvement in steam consumption for the following temperature increases in degrees F.:

Between 0 and 100 deg. F. superheat for each 10 deg.
Between 100 and 200 deg. F. superheat for each 12 deg.
Between 200 and 300 deg. F. superheat for each 14 deg.

In the case of wet steam, where the steam consumption is measured as condensate, the effect is that for every 1 per cent wetness the apparent consumption must be decreased by 2 per cent.

Vacuum Correction Is Important

3. Correction for vacuum is of far greater importance than that for either pressure or superheat and the desirability of keeping the corrections to be applied as small as possible must, therefore, be emphasized. For this reason, it should be considered of paramount importance during a test to endeavor to maintain the vacuum as little different as possible from that for which the turbine was designed.

Theoretically the correction factor increases rapidly with each decrease of terminal pressure; the actual increase, however, is usually not so great for the following reason: The volume of steam passing through the last stages of the turbine will vary approximately inversely with the terminal pressure and, as it is not commercially possible to provide sufficiently large blade area at the exhaust end to deal efficiently with the increased volume of steam at low terminal pressures, the ratio of the blade speed to the steam speed will decrease, the turbine efficiency following.

Actual gain due to decreased terminal pressure is, therefore, not so great as the theoretical; its actual value is intimately bound up with the turbine design and is satisfactorily determined only from actual tests.

The following corrections are generally accepted for high-pressure turbines and hold good between saturated temperature and 300 deg. F. superheat.

Steam pressure lb. sq. in. gage	Specified vacuum	Per cent correction for 1 in. variation of vacuum Full load	¾ load	½ load	¼ load
180	26	3.0	3.8	4.7	6.5
	27	3.7	4.6	5.5	7.6
	28	5.7	6.2	7.6	9.7
	29	7.4	8.5	10.3	12.8
140	26	3.1	4.2	5.1	6.8
	27	3.8	4.7	5.8	8.0
	28	5.2	6.2	7.7	10.2
	29	7.8	8.6	10.6	13.5
100	26	3.6	4.5	5.5	7.5
	27	4.2	5.2	6.4	8.7
	28	5.7	6.5	8.3	10.9
	29	8.4	9.4	11.5	14.5

In the case of back-pressure turbines or the high-pressure end of reducing turbines, all the necessary corrections will be considerably greater than those here given and require separate consideration. At the best, any correction made is only an approximation and it is, therefore, essential that every effort be made to arrange the test conditions so that all adjustments to the observed results are as small as possible.

In connection with turbine tests, it is of the utmost importance to note where the measurements of steam pressure, superheat and vacuum are taken. The usually accepted points are, of course, before the turbine stop-valve and at the turbine exhaust flange. The efficiency of the net output at the coupling (or at the alternator terminals) based on conditions measured at the foregoing points is the most important practical consideration. It would appear that some recently published test results, in which a very high turbine efficiency was claimed are based upon steam and vacuum measurements taken at unusual points. While the analysis of the efficiency essentially depends upon measurements at intermediate points, the overall efficiency of the turbine must be based upon steam conditions taken before the stop-valve and vacuum at the turbine exhaust flange; hence, in comparing efficiencies it is essential that the basis should be carefully examined.

The effect of taking the steam pressure after the throttle valve has been mentioned above and, in connection with the measurement of vacuum, it may be stated that it seems probable that much larger differences in pressure occur in the turbine exhaust branch than is generally believed. The actual point of measurement, therefore, is of considerable importance.

Consumers Power Co., Jackson, Mich., has authorized plans for an addition to its steam-operated electric generating plant at Zilwaukee, near Saginaw, Mich., to provide for an increase of 35,000 kw. in capacity, making a total rating for the station of 108,500 kw. The new installation will consist of turbo-generating unit, four watertube boilers, equipped with economizers and air pre-heaters, pumping equipment, switchboard apparatus and accessories. The expansion is estimated to cost more than $2,000,000, including transmission line extensions at a later date.

Bellows Falls Hydroelectric Development

New England Power Association Plant in Vermont Set on Rock Ledge Through Which Draft Tubes and Tailrace Are Cut. By C. E. Anderson*

AT BELLOWS FALLS, Vt., on the Connecticut River, the New England Power Association has recently put into operation a 60,000-hp. hydroelectric development. Conditions at this point were favorable for developing a fall of 60 ft. with an average flow of 10,000 sec. ft. The complete development, Fig. 1, consists of concrete dam with flood control equipment, canal, power house containing three hydraulic-turbine-driven generators of 20,000 hp. capacity each, tailrace and outdoor switching stations. The concrete dam is 620 ft. long, with an average height of about 18 ft. It is equipped with two roller flood gates and three bays of flashboards. This equipment will be described in detail in a subsequent article; the following discussion treats of the power house only.

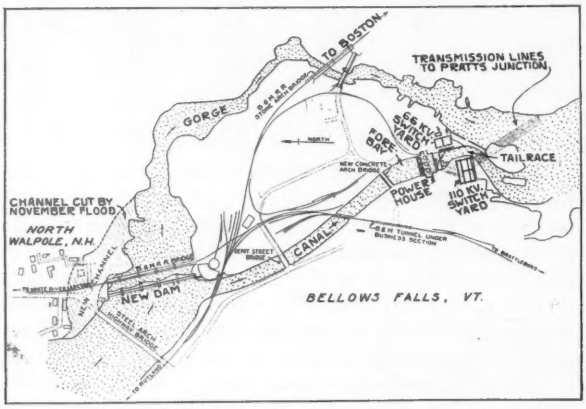


FIG. 1. GENERAL PLAN OF BELLOWS FALLS DEVELOPMENT

Power House Contains Three Units

This power house has a concrete substructure and a superstructure measuring 42 ft. by 182 ft. and is constructed of brick and steel. The main building is adjoined by an enclosed headworks building measuring 29 ft. by 135 ft. and an electrical building measuring 33 ft. by 130 ft., both of brick and steel construction. The power house equipment, Fig. 2, includes three General Electric Co., 3-phase, 60-cycle, 6600-v., 17,000-kv.a., 85.7-r.p.m. vertical generators driven by S. Morgan Smith Co. Francis type hydraulic turbines. Generators are of structural steel construction, the only castings used being for the rotor hub and spokes. Each unit furnishes its own excitation, the exciter being located over the generator and directly connected to the generator shaft. The Gibbs thrust bearing is located between the generator and the turbine and is supported on a steel bridge which spans the wheel pit, as shown in Fig. 3. This construction eliminates the usual lower guide bearing and in consequence the lower spider on the generator. With this arrangement, the generator rotor can be removed for repairs without disturbing the thrust bearing.

Each hydraulic turbine, Fig. 3, consists of a concrete scroll case, cast-iron runner, column bolt design speed ring, cast-steel gates and a concrete-lined draft tube. As the power house site is on a high point of ledge, it was necessary to tunnel through the rock in building the draft tubes. The draft tube drops 50 ft. below the center line of the unit. Horizontal distance from center line of unit to the outlet is 100 ft. The tailrace is also cut out of solid rock. Turbine gates are operated by servo-motors, which in turn are regulated by an S. Morgan Smith Co. governor. This governor is equipped with motor-driven flyballs and an automatic synchronizing device. The steady bearing over the turbine cover plate is of the adjustable, lignum-vitae type. Flow of water through the units is at all times recorded by Venturi meters.

Railroad siding is brought into the power house from

*Assistant Engineer, New England Power Construction Co.

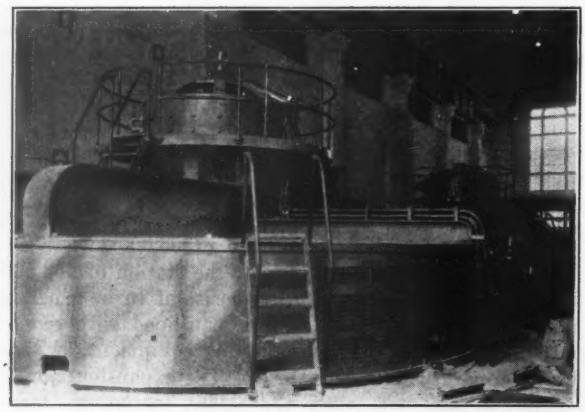


FIG. 2. TWO OF THE THREE 17,000-KV-A. GENERATORS

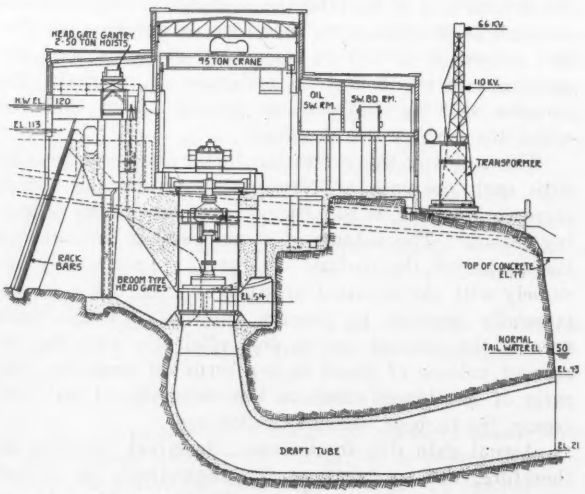


FIG. 3. CROSS-SECTION OF BELLOWS FALLS POWER HOUSE; THRUST BEARING SUPPORTED ON BRIDGE BELOW GENERATOR

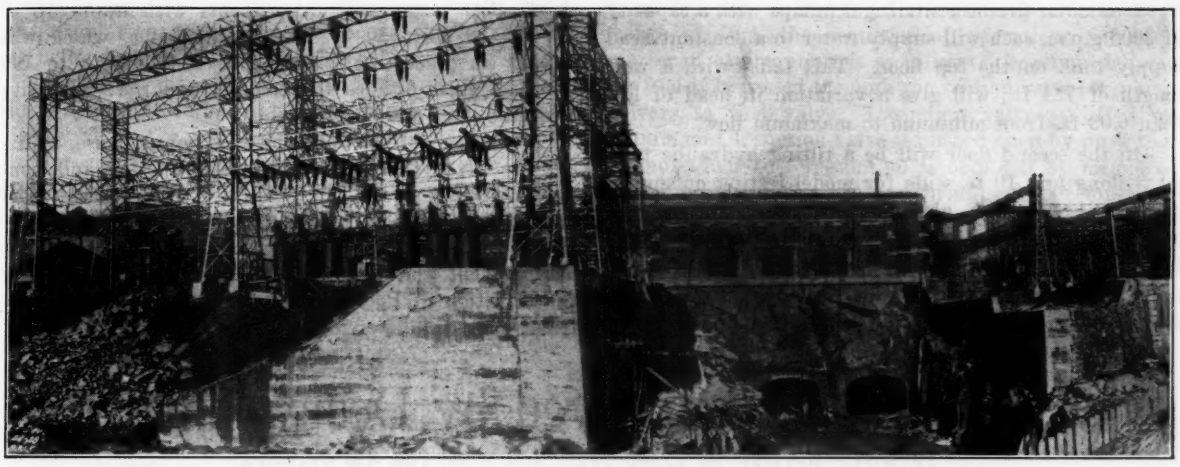


FIG. 4. LOOKING UP-STREAM AT POWER HOUSE; TAIL-RACE AND TWO DRAFT TUBES ARE SHOWN; AT LEFT IS 110-KV. SWITCHYARD AND AT RIGHT 66-KV. YARD

which material can be unloaded from cars by a Niles crane with a 95-t. main hook and a 10-t. auxiliary hook. Auxiliary power house equipment is noted in the accompanying list.

Power Is Stepped Up to 66 and 110 Kv. for Transmission

On the main floor is the bus structure, downstream from the generators, Figs. 3 and 4. Current normally

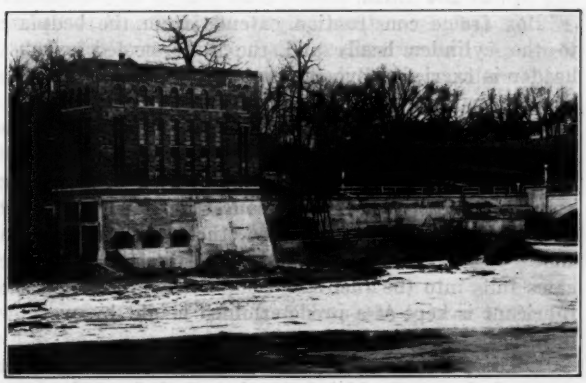
Mechanical and Electrical Equipment Installed at Bellows Falls Hydroelectric Plant

Equipment	Manufacturer	Size	Remarks
Flood gates	S. Morgan Smith Co.	13 ft. 5½ in. by 121 ft.	Roller type
Gantry crane	Milwaukee Elec. Crane Co.	25 t.	For flashboard operations
Ice sluice gate	S. Morgan Smith Co.	10 ft. by 12 ft.	
Sluice gate hoist	Phillips & Davies, Inc.		
Mechanical rake	Newport News Shipbldg. & Dry Dock Co.	19 ft.	
Head gates and hoists	Phillips & Davies, Inc.	17 ft. 4½ in. by 24 ft.	Broome type gates
Filler gates and hoists	Coffin Valve Co.	2 ft. by 3 ft.	
Power house crane	Niles Crane Corp.	95 t.	10-t. auxiliary hook
Generators	General Electric Co.	17,000 kv.a.	3 units—vertical type
Turbines	S. Morgan Smith Co.	20,000 hp.	3 units—Actuator type
Governors	S. Morgan Smith Co.	115,000 ft.-lb.	vertical Francis
Air compressor	Sullivan Machinery Co.	176 c.f.m.	For station service
Air compressor	Lipman	15 c.f.m.	For oil press tank and air brakes
Pumps	Allis-Chalmers Mfg. Co.	350 c.f.m. centrif.	Transformers and bearing cooling water
Transformers	General Electric Co.	17,000 kv.a.	3 units
Switchboard	General Electric Co.		

flows from the generator through a transfer bus to 6600-v. oil switches, located on the balcony floor in a compartment directly in front of the switchboard room. From here the current returns to a second transfer bus and thence to the 6600-66,000-110,000-v. transformers. These transformers are located outside of the building on a rock bench directly over the draft tube tunnels. The transformers may be taken into the power house for maintenance by means of a transfer truck. Current passes from the transformers to 66,000-v. and 110,000-v. switching yards located on either side of the tailrace. Energy is supplied by 6600-v. cables to the Fall Mountain Electric Co. local substation for industrial and lighting service in the Bellows Falls district. Lines at 44,000 v. feed north into New Hampshire and Vermont, connecting with the Vermont Hydroelectric Corp.'s system at Charleston, N. H. The 66,000-v. substation ties south in Vermont to Putney and Vernon. A double circuit steel tower line on private right-of-way delivers energy at 110,000-v. to an important switching station at Pratts Junction, Mass., from which point 66,000-v. lines radiate to load centers in New Hampshire, Massachusetts and Rhode Island.

University of Iowa Builds New Hydraulic Laboratory

AT IOWA CITY, the first section of the new University of Iowa hydraulic laboratory on the Iowa River is nearing completion. This section, 30 ft. wide and 60 ft. long, designed to allow for future extension to an ultimate length of 150 ft., will be one of the finest and most complete hydraulic laboratories in this country.



FIRST SECTION OF THE NEW UNIVERSITY OF IOWA HYDRAULIC LABORATORY UNDER CONSTRUCTION

Two motor-driven centrifugal pumps with a capacity of 3000 g.p.m. each will supply water to a constant head supply tank on the top floor. This tank, with a weir length of 724 ft., will give a variation in head of less than 0.03 ft. from minimum to maximum flow.

On the second floor will be a tilting hydraulic tank 50 ft. long and 10 ft. wide for model testing or similar work and a 3 by 3-ft. glass model flume 50 ft. long, the only one of its kind known in America. On the lower floor two 20,000-lb. weighing tanks will be located, with the piping arranged so that the water can be weighed and discharged to volumetric measuring basins if desired. For large scale experiments with heads up to 10 ft., the large 10 by 10-ft. river flume, which was already in place, has been increased in length to 190 ft. The river divides the campus and the University owns the dam and water rights.

At one end of the dam, the new power house, utilizing the river flow for hydroelectric power and condenser cooling water, has been built and, at the other end, the new hydraulic laboratory is under construction. With the exception of the architectural details, the arrangement and design of the laboratory was under the direction of Professor Floyd Nagler, assistant professor of hydraulic engineering.

Diesel Operation Improved by Design Features

IMPROVED METHODS OF LUBRICATION AND FUEL AND AIR STARTING CONTROL CHARACTERIZE NEW FULTON DESIGN. BY H. F. BIRNIE

INTEREST IN SOME of the principal construction features of the recently built Fulton Diesel engines follows from their splendid performance, demonstrated in the tests published in the August 1 issue. This model

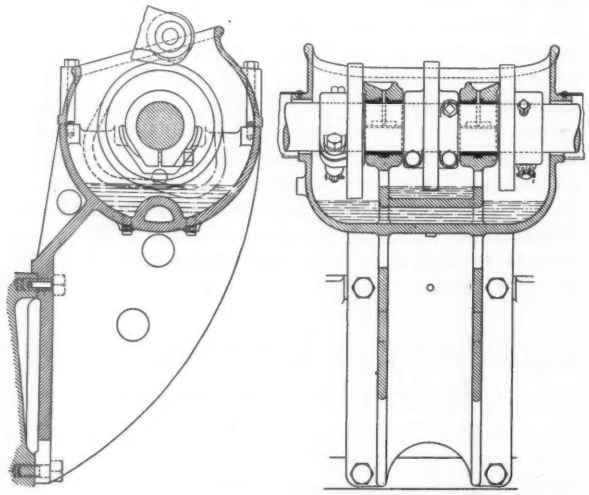


FIG. 1. OIL POCKETS PROVIDE MEANS FOR LUBRICATING CAMS AND ROCKER ARM ROLLERS

of engine is of the 8-cylinder, 4-cycle type developing 911 hp. at 204 r.p.m.

Box frame construction extends from the bedplate to the cylinder heads and the water-cooled exhaust header is carried above the platform. The governor is located on the engine bedplate.

All housings of the engine, except the one at the vertical shaft, are alike. They are so arranged that the cams and rocker arm rollers are lubricated by splashing and, as the fuel cam is the smallest in diameter, its oil compartment is higher than the other compartments, as shown in Fig. 1, so that oil splashed from the two other cams falls into the fuel cam compartment in which the lubricant is kept at a predetermined height by overflow openings.

Oil is prevented from creeping along the camshaft by a splash guard which is fitted around the rocker-arm rollers which intercept the oil that is splashed sideways between the rocker-arm roller and the cam and causes it to fall back on the cam. As the cam is greater in diameter than the cam-shaft, the centrifugal force, when the shaft is rotating, prevents the oil from flowing to the shaft.

Three methods of lubrication are used: The camshaft bearings, cams and rocker arm rollers are lubricated by the splash system; the power and compressor cylinders are oiled by pressure sight-feed lubricators driven from the camshaft and the main bearings are lubricated by a steady stream of oil delivered by a gear pump driven from the crankshaft at the compressor end.

In the latter system, the lubricating oil is forced by the gear pump through a cooler to a header placed inside of the engine frame and extending through it to the main bearing at the flywheel end. Leads convey the oil from this header to each main bearing and then through a hole drilled in the crankshaft to the crankpin bearing. The oil then flows through the hollow connecting rod to the piston pin. Surplus oil drips into the bedplate and runs back into the settling tanks.

OIL PREFERABLE TO GREASE FOR GEARS

This system also lubricates the upper vertical shaft and camshaft gears. Use of oil for these gears has been found to be superior to the former method of employing a heavy gear compound since, in case of excessive wear under the latter method of lubrication, the fine metallic particles which are worn off are held in suspension and mix with the grease forming a cutting compound, instead of settling out as when oil is used. The gear compartment at the lower end of the vertical shaft is fed with the surplus oil from the main bearings and the level is maintained by an overflow to the engine bedplate. Connected in a lead from the upper end of the vertical shaft is a sight feed which provides for regulation of the flow; most of the surplus oil being drained back through a separate pipe to the engine bedplate and a part of it draining to the lower gear along the vertical shaft, as shown in Fig. 2.

Grooving of the bearings in a pressure lubricating system differs from that of a sight-feed system. The central groove runs in the path of the crankshaft lubricating holes leading to the crankpin bearing. Babbit

is cast integral in the main bearing cap except for a semi-circular space opposite the groove, the lower bearing being formed by a detachable babbit shell.

In a similar manner, the crankpin bearing is grooved but is made of two babbit shells each of which extends slightly above the box and presses against the other to prevent shifting. The piston pin bearing is a single babbit shell, split at the top to fit the shims of the connecting rod. The pressure in the lubricating oil

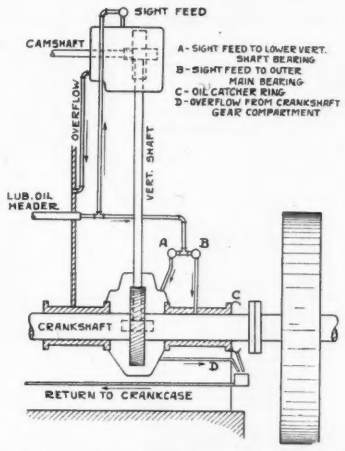


FIG. 2. GEAR-PUMP FORCES LUBRICATING OIL, IN SEQUENCE, THROUGH A NUMBER OF PRINCIPAL BEARINGS

header is kept at 20 lb. An electric signal, which warns the operator when the pressure drops below a predetermined point, is fitted to the pressure gage.

Settling Tanks Remove Suspended Particles

Standard equipment provides for a water-cooled oil cooler, three settling tanks and one auxiliary hand-driven gear pump which is used for priming the main bearing before starting the engine and for transferring oil from one settling tank to another. Each settling tank has a capacity of over 100 gal. One tank is used at a time, the second tank containing dirty oil. When the oil in the latter has settled its impurities, the clean oil is pumped into the clean spare tank.

Intake and exhaust cams are alike and hence interchangeable. In assembling the cams, they are first clamped to the shaft and, after each is set in its correct position, it is fastened by an additional set-screw which penetrates the shaft. The fuel cam, which is made of chilled cast iron, is supplied with a set screw which rests against the shoulder of a notch in the camshaft, providing easy adjustment of the fuel injection lead.

Centralized Governing

Each cylinder is served by an individual fuel pump which is driven by an eccentric on the camshaft, as shown in Fig. 3. There are no separate bypass valves, the suction valves fulfilling the functions of both bypass and suction valves. Governoring is centralized and the governor functions through a system of levers one of which is shown in Fig. 3 at A. This is fastened on the shaft B and turns the eccentric C by means of the rod D, thereby increasing or decreasing the clearance between the lever E and the suction-valve push rod.

Even at maximum load, only half of the cam lift is needed for delivery. In admitting a maximum charge of fuel, the sequence of operations for each quarter of cam contour is as follows: 1, pump delivers but fuel is bypassed through the suction valve; 2, pump delivers to fuel valve; 3, suction valve is lifted by vacuum and 4, suction valve is pushed open by push rod.

Individual fuel regulation is obtained by means of the set screw in lever E and priming is accomplished by means of a rod fitting into a hole in lever F. To guard the pump against air-binding, fuel oil is introduced in the pump through G, to a level above the pump plunger.

Accurate and Convenient Indicator Motion

Indicator motion developed for this engine is not only convenient but exceptionally accurate. It operates by means of a set of disks which are fastened on top of the vertical shaft and rotate at engine speed as shown in Fig. 4.

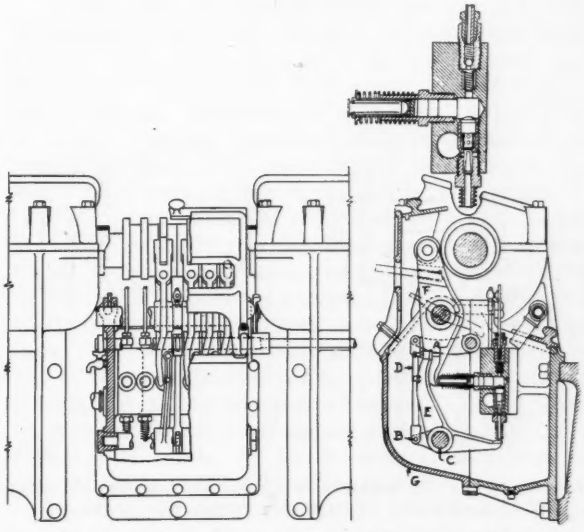


FIG. 3. INDIVIDUAL FUEL PUMP SERVES EACH CYLINDER BUT GOVERNING IS CENTRALIZED

Movement is given to a crosshead by means of connecting link A, which bears the same ratio between its length and the length of stroke of the crosshead as the length of the engine connecting rod bears to the stroke of the engine. From the crosshead, the movement is transmitted to a light steel tubing which extends along the entire length of the engine and passes through the hollow fulcrum of the valve rocker arms. At each cylinder head, a short cord is led through rollers from the steel tubing to the indicator petcocks. Coupling B permits setting the indicator motion into action at will. Disk C is provided with a number of tapped holes, corresponding to the top dead centers of the different cylinders to which connecting link A can be fixed. A disadvantage of this arrangement is that the cylinders cannot be indicated simultaneously; however, this is rarely done in practice.

Starting air is admitted into the power cylinder while the valves are injecting fuel. The starting system comprises a low-pressure starting air reservoir, starting valves on each cylinder and starting air pilot valves, one for each starting valve. These valves, which are

actuated by cams fixed on the camshaft, control the action of the starting valves.

Air Piping Distribution

Distribution of the air piping on the engine is shown in Fig. 5. The compressor high-pressure stage feeds into the injection air bottle from which the air passes to the fuel valves F. The connection between the injection air bottle and the starting air reservoir permits filling the latter. The starting air flows from the starting air reservoir not only to the starting valves S but

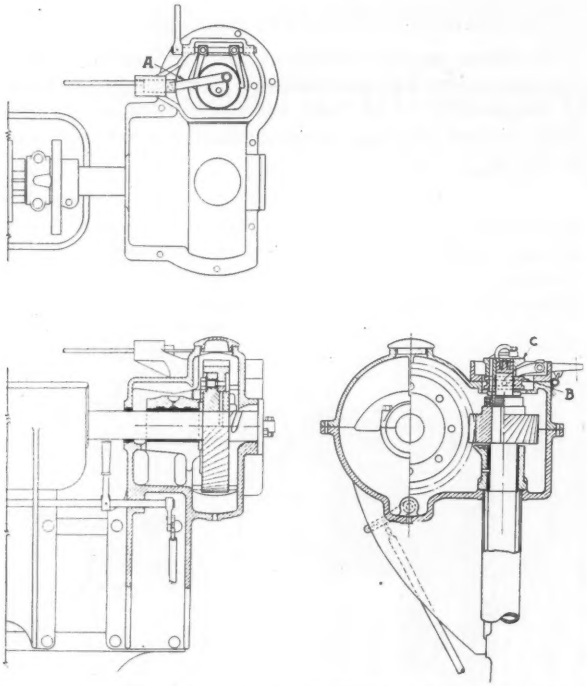


FIG. 4. HELICAL GEAR ATTACHED TO CAMSHAFT SUPPLIES DIRECT ACTION TO INDICATOR MOTION

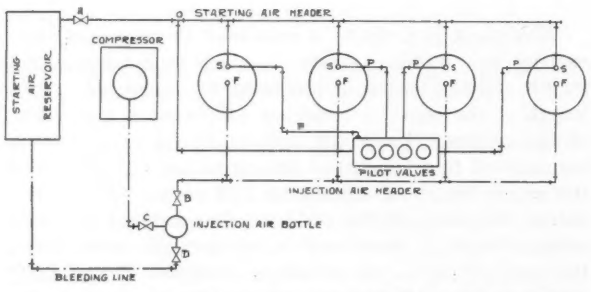


FIG. 5. ARRANGEMENT OF AIR LINES AND FITTINGS PERMITS OF EQUAL PRESSURE IN ALL PIPES OF STARTING SYSTEM

also through the branch line at O to the pilot valves. Separate pipes lead the air from the latter to the top of each starting valve providing the same air pressure in all the pipes of the starting system.

Action of the starting valve will be understood by referring to Fig. 6. Starting air coming through the large pipe at the right cannot open the valve as the surface area of piece A is larger than that of valve head B minus the cross-sectional area of the stem and when the pilot valves are not operating, the pilot air lines are not under pressure. When pilot air is served to the starting valves by the pilot valve, the pressures on both sides of piece A balance and the starting air pressing on the valve head B opens the starting valve.

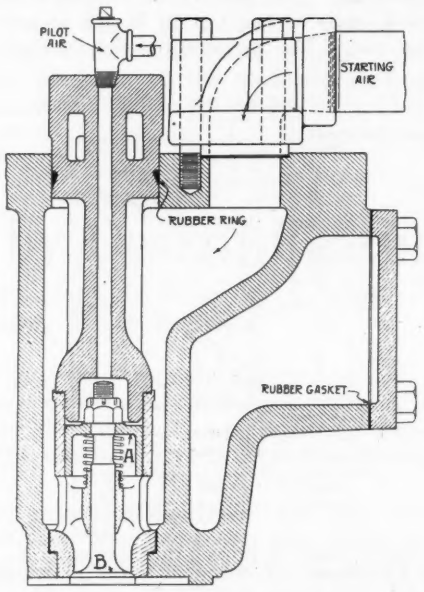


FIG. 6. DIFFERENTIAL CONSTRUCTION PERMITS STARTING VALVE TO OPERATE AUTOMATICALLY

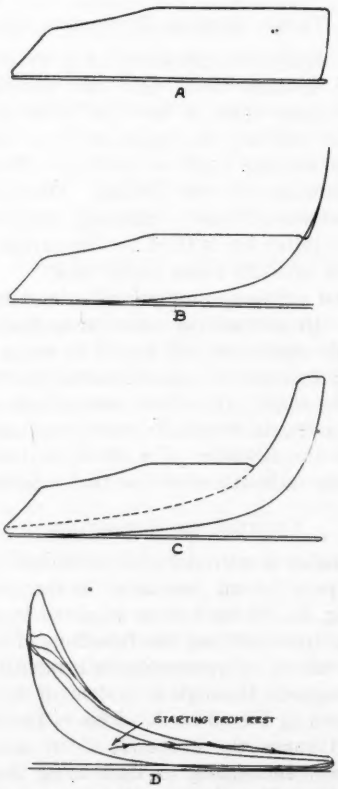


FIG. 7. THEORETICAL STARTING INDICATOR CARDS SHOW SEQUENCE OF ACTIONS

When the pressure inside of the combustion chamber of the cylinder is great enough to counteract this downward pressure of the starting air, the starting valve stays closed, the action taking place in sequence as indicated by the theoretical starting cards shown at A, B and C in Fig. 7. The first card A shows the diagram obtained before compression in the cylinder has been built up; the second, B, with the usual compression pressure and C, with the engine firing. Frequently the second diagram does not show up in practice as indicated at D, which is an actual card taken during starting. The pilot valves are set to act on firing top dead

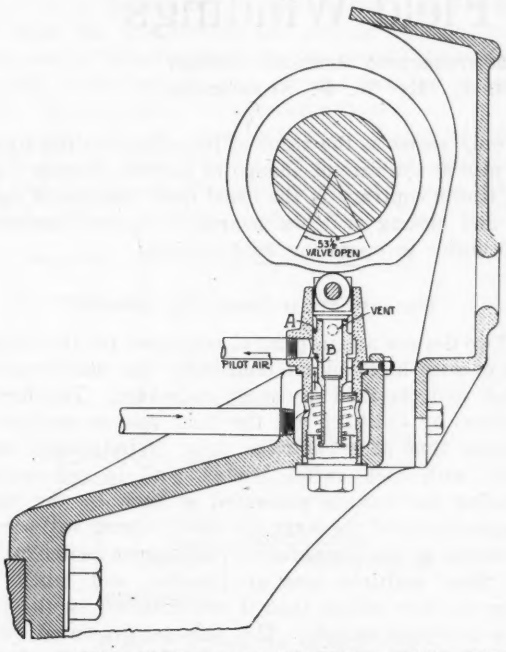


FIG. 8. CAMS CONTROL AIR STARTING PILOT VALVES

center but only the closing of the starting valve is actually controlled, the time of opening depending upon the pressure inside of the cylinder.

Action of the air starting pilot valves is controlled by cams fixed on the camshaft. The valve is shown in open position in Fig. 8, the pilot air being free to flow to the starting valve. In closed position the edge A not only closes this connection but uncovers the edge B, thereby permitting the compressed air in the upper line to escape through the vent hole so as to relieve the pressure.

In starting the engine, valves A, B and C, Fig. 5, which are located close together, are opened in sequence. As soon as the engine fires, A is closed and D opened so as to refill the starting air reservoir.

CITY ICE & FUEL CO., Cleveland, Ohio, has concluded negotiations for a merger with the Polar Wave Ice & Fuel Co., St. Louis, Mo., and the Tulsa Ice & Coal Storage Co., Tulsa, Okla., and operations in the future will be carried out under the control of the first noted organization. The consolidated company will be capitalized at $60,000,000, and will have a chain of 91 ice-manufacturing plants in different parts of the country, as well as a series of cold storage and refrigerating plants in various sections.

Use of Solid Carbon Dioxide for Refrigeration

SOLID carbon dioxide, which has a temperature of 109 to 114 deg. below zero, has long been known as a scientific curiosity, but as a result of better and cheaper methods of manufacturing, it has recently received much attention as a possible commercial refrigerant for railway cars, cold storage rooms and ship holds. A great deal has been published in the popular press to the effect that it is capable of working wonders in all lines of refrigeration.

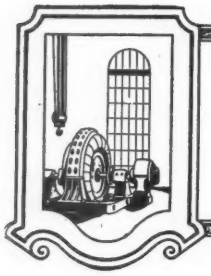
Its great cooling power and its freedom from drip are interesting and attractive features but the fact seems to be overlooked, says Dr. Charles Brooks of the Bureau of Plant Industry, United States Department of Agriculture, that the carbon dioxide gas given off by the new refrigerant may, under certain conditions, be distinctly harmful to fresh fruits and vegetables.

"When removed from the parent plant or dug from the ground," says Doctor Brooks, "fruits and vegetables are still alive and remain alive during shipment and storage and as long as the fresh product is in a marketable condition. Like other living material, either plant or animal, they are carrying on respiration, taking up oxygen and giving off carbon dioxide and they can not stand great and prolonged changes in the oxygen or carbon dioxide content of the surrounding air. It has been well established in botanical literature that continued exposure of peaches, pears, apples, strawberries or cranberries to high percentages of carbon dioxide will result in the development of objectionable flavors and it has been shown that certain storage troubles of apples and potatoes are the result of an accumulation of carbon dioxide and the displacement of oxygen. Heavy losses in overseas shipments of apples and pears have been found to be caused by an excessive accumulation of carbon dioxide in the hold of the ship.

"With these facts in mind, it is evident that the use of the new refrigerant can not be considered as merely a problem in physics and refrigeration but, in so far as the shipment of living material is concerned, is largely a question of the tolerance of the particular fruit or vegetable to the accumulation of carbon dioxide in the storage air. This tolerance varies with the variety and maturity of the product and our present knowledge of the subject is far too meager to serve as a basis for commercial procedure. Under such conditions, indiscriminate popularizing of the new refrigerant is untimely and may have dangerous possibilities.

Economizers and Superheaters Help Small Boilers

IN THE article under the above title appearing in the July 15 issue are several errors which were inadvertently overlooked. The second line of the second paragraph in the right-hand column, page 770, should read: "parts of these are lightly packed with insulation to—" Last line of the text in the left-hand column, page 771, should read "foreign material can be blown out in suspension through the blow-off." The second line, right-hand column, page 771, should read "to form a hard scale and the foreign matter is easily—." Also Fig. 3, page 771 is printed upside down.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Induced Voltages in Field Windings

THEORY OF ARC FORMATION, METHODS OF COUNTERACTING DAMAGING EFFECT OF ARC. SELF INDUCTION IN A.C. CIRCUITS. BY W. F. SUTHERLAND

MOST READERS are familiar with the vicious spark or arc occurring on the interruption of a highly inductive circuit. The make and break spark system for ignition purposes is an example where good use is made of this phenomenon. At other times, the inductive arc is decidedly a nuisance and is likely to cause severe damage unless counteracted in some way. The field windings of dynamo-electric machinery, consisting (for the shunt windings) of many turns of wire plus a good magnetic circuit are highly inductive and especial care has, therefore, to be taken in opening them whenever this may be required. Otherwise the high voltages created at the instant of rupture are liable to lead to insulation breakdown or may even prove dangerous to the operator.

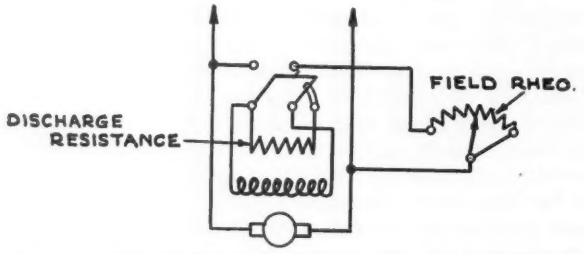


FIG. 1. CIRCUIT SHOWING THE USE OF FIELD DISCHARGE RESISTANCE

ARC DUE TO ENERGY STORED IN THE FIELD

Whenever an inductive circuit is closed on some source of current, the final value of current strength, that which might be expected in view of voltage and current considerations is not obtained until an appreciable time has elapsed. During this interval internal energy is being stored up in the magnetic circuit and this energy remains constant or unaltered in amount, assuming of course that we are dealing with direct current, just so long as the current strength is maintained at a constant value.

Now, should the circuit be interrupted, the stored up energy must be dissipated in some one form or another. If the circuit is opened by a knife switch or some similar device, it is absorbed by the arc occurring and the quicker the break the higher the voltage and the more wicked the arc. The voltage of self-induction not only varies as the value of inductance in the circuit but also as the rate of change of current flowing. For this reason contrary to the usual good practice of opening and closing switches smartly, a slower movement is desirable in operating field switches.

USE OF FIELD BREAK-UP SWITCH

Two devices are in general employed for the mitigation of such high voltage transients—the field break-up switch and the field discharge resistance. The former operates by splitting up the field into a number of sections, thus decreasing the value of inductance associated with each switch contact and in consequence reducing the voltage generated at each by the rapid disappearance of the magnetic flux. Arcing still occurs, of course, at the comparatively numerous switch points but these multiple arcs are smaller and much less severe in their effects than if concentrated on the jaws of a two-pole switch. The voltage generated being lower in proportion to the number of sections employed, the field windings are also subjected to much lower stresses and are not so likely to puncture and go to ground.

FIELD DISCHARGE RESISTANCE

The field discharge resistance works in a slightly different fashion, since while the value of inductance across the switch remains the same, the time during which the field can discharge itself is lengthened indefinitely and is no longer dependent on the snappiness with which the operator opens the switch. In Fig. 1 it will be noticed that instead of a multi-contact knife switch, only a double-pole switch is required. This, however, is fitted with an auxiliary contact, making contact before the main contacts are fully open. A resistance is inserted by this means across the field when its source of excitation is cut off. Thus the induced voltage, instead of dissipating itself in the form of an arc, causes current to flow quietly through the resistance until the energy in the field is absorbed.

CALCULATION OF FIELD DISCHARGE RESISTANCE

Such field discharge resistance can be calculated by assuming that the inductive energy of the field tends to maintain the flow of current at the same strength as before opening the field switch. This gives an upper

limit to the current strength which cannot be exceeded. Since the voltage resulting across the fields will be equal to the IR drop through the resistor, the problem becomes a simple one, once the safe value for this voltage is determined. It should be well within the test voltage applied to the fields on the test floor, say about one-half.

Thus for a 220-v. field the test voltage would be about 1500 v. Half of this voltage, or 750, would be safe and for the sake of example if the normal field current were about 20, the resulting required resistance would be 37.5 ohms.

As to the carrying capacity required, that is another matter. It is determined by two factors, the energy input from the field, which can usually be neglected and the energy absorbed from the line should the switch be opened slowly and the line current flow for several seconds. This latter is the governing factor.

According to the Standardization Rules of the A. I. E. E., the field windings of alternators shall be tested with 10 times exciter voltage but in no case with less than 1500 v. or more than 3500 v. Field windings of synchronous machines such as motors which are to be started up with alternating current are to be tested as above, when the fields are closed during the starting period. With the fields open circuited and sectionalized, they shall be tested with 5000 v. When machines are to be started with fields open circuited and all connected in series, the windings shall be tested with 5000 v. for less than 275 v. excitation and 8000 v. for excitation of 250 to 750 v.

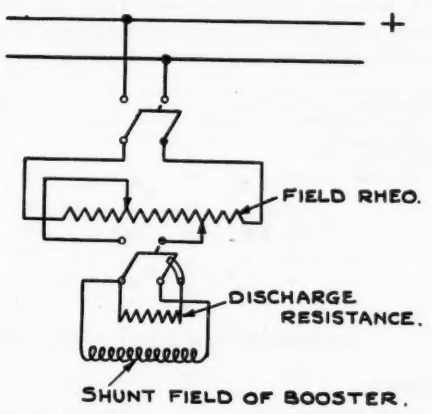


FIG. 2. USE OF DOUBLE POLE SWITCH IN THIS BOOSTER CIRCUIT OVERCAME TROUBLE

Converter fields are to be tested as above except for those open-circuited and all in series during starting. In this latter case, the windings are to be tested with 5000 v. for less than 275 v. excitation, 8000 v. for excitations between 275 and 800 v. and 10 times the exciting voltage for excitation of more than 800 v.

Direct current machinery is to be tested with an alternating voltage of an r.m.s. value twice the rated voltage of the machine plus 1000.

While the induced voltage due to circuit interruption is most commonly met with, induced voltages arising from other causes are occasionally encountered, particularly on alternating current apparatus and these must be considered at times since they create special problems all their own. Going back to fundamentals, it is, of course, understood that electro-motive force is created by a change of flux interlinkage with a conductor. The transformer depends on this fact for its operation and the rotary converter at stand-still is much like a transformer. Impress voltage across the rings of a converter and a rotating field of flux is set up by the current through the armature. This flux, in its sweep past the poles of the field, cuts the conductors thereon and inevitably sets up an electro-motive force, alternating in character, and at first of a frequency equal to that of the supply circuit. As the machine builds up in speed, the frequency gradually decreases, smoothing out to a zero value at synchronism. The self-starting synchronous motor or condenser generates the same type of variable frequency voltage in its field windings on starting.

Case of Trouble on Booster Converter

Induced voltages sometimes cause trouble in parts of field circuits designed for normal operating conditions but with not sufficient provision for the high voltages and heavy currents obtaining during the starting period. The writer has in mind a booster converter which caused trouble through the rheostat on the booster field burning out at times. The circuit is shown in Fig. 2. The rheostat is provided with two face plates with independent contact arms, these being connected to the booster field while the outside terminals of the resistance were connected to the source of excitation. The booster field voltage, consequently the generated voltage in the armature, was thus variable in steps from full buck to full boost.

During the starting period, the heavy currents induced in the field windings proved too much for the rheostat, unless both arms were set at the same point in which case the resistance grids would be shorted out of circuit. This point was difficult to determine with accuracy and in consequence a double pole double throw switch was installed as shown in the diagram. This performed two functions, it cleared the rheostat and also shorted the field windings allowing the induced current to flow without excessive voltage. A field discharge resistance was also incorporated in the switch, in case some forgetful operator should chance to open the switch under conditions of normal field excitation.

Incidentally, it is advisable sometimes to connect a field rheostat in circuit as shown in Fig. 1 where both ends of the resistance unit are connected up, one to the exterior circuit leading to the fields, the other to the moving arm. No effect is noticed on the normal operating characteristics of the rheostat except the beneficial one of eliminating arcing at the contacts due to poor contact. This kink frequently proves useful.

To co-operate with the government in directing aviators at night, the smokestack of the Pueblo plant of the Southern Colorado Power Co., 250 ft. high and 14 ft. in diameter at the base, is to be lighted by eight 500-w. floodlamps. They will cause the stack to appear as a huge illuminated cylinder.

Cedar Falls, Iowa, municipal light plant has been granted authority to erect and maintain high power electric transmission lines from the city limits three miles south and east to the Grundy county line.

Electricity---What It Is and How It Acts*

PART VII. IONIC AND ELECTRONIC CONDUCTION. CONDUCTION IN LIQUIDS. IONIZATION DUE TO DISSOCIATION OF MOLECULES

IN OUR DISCUSSION of electric conduction through gases in the preceding article,[1] it was shown that a gas was rendered conducting if we introduced among the molecules of gas, a number of free electrons. These "unattached" electrons moving under the action of the electric field between oppositely charged plates ionized

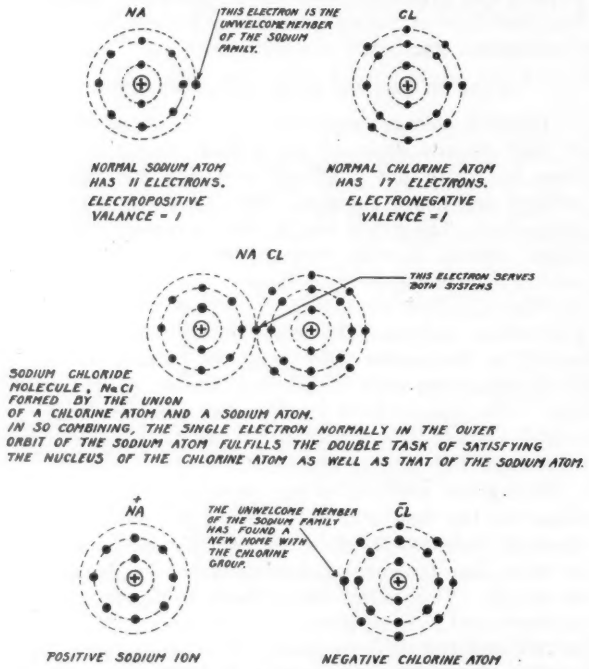

NA
THIS ELECTRON IS THE UNWELCOME MEMBER OF THE SODIUM FAMILY.
CL
NORMAL SODIUM ATOM HAS 11 ELECTRONS.
ELECTROPOSITIVE VALANCE = 1
NORMAL CHLORINE ATOM HAS 17 ELECTRONS.
ELECTRONEGATIVE VALENCE = 1
NA CL
THIS ELECTRON SERVES BOTH SYSTEMS
SODIUM CHLORIDE MOLECULE, NaCl FORMED BY THE UNION OF A CHLORINE ATOM AND A SODIUM ATOM.
IN SO COMBINING, THE SINGLE ELECTRON NORMALLY IN THE OUTER ORBIT OF THE SODIUM ATOM FULFILLS THE DOUBLE TASK OF SATISFYING THE NUCLEUS OF THE CHLORINE ATOM AS WELL AS THAT OF THE SODIUM ATOM.
+
NA
THE UNWELCOME MEMBER OF THE SODIUM FAMILY HAS FOUND A NEW HOME WITH THE CHLORINE GROUP.
CL
POSITIVE SODIUM ION
NEGATIVE CHLORINE ATOM

FIG. 1. ATOMIC ARRANGEMENT OF THE SODIUM CHLORIDE MOLECULE SHOWING THE PROCESS OF IONIZATION DUE TO DISSOCIATION

The normal sodium atom has one electron in its outer orbit which it would like to lose. The chlorine atom on the other hand lacks one electron in the outer orbit to give the system stability. As a consequence these two atoms readily combine to form the molecule of salt shown at the center. In dissociation the salt molecule splits up again but the chlorine atom retains the single electron from the outer orbit of the sodium atom. The residue of the sodium atom is left with a positive charge while the chlorine ion has a negative charge.

neutral atoms of gas, thus producing additional free electrons as well as positive ions, both of which are effective in causing the discharge of the plates. If, by means of an electric battery or a dynamo, the plates are maintained in a continuously charged condition, an electric current will be maintained across the gas space.

This type of electric conduction is known as ionic conduction because it makes use of ions, that is, electrically charged atoms of matter. It will be remembered, however, that we considered also, rather briefly, the case where no normal atoms of gas were present between the plates, that is, in a perfect vacuum, and where conduction was effected entirely by the transference of electrons from the negatively charged plate to the one carrying the positive charge. This type of conduction is known as electronic conduction to differentiate it from ionic conduction. All processes of conduction, whether in gases, in solids, in liquids or in vacuum, can be classified under either of these headings.

While, in a general way, ionic conduction may be thought of as applying to gases and liquids and electronic conduction as applying more particularly to solids, this is strictly not true. There are solid bodies that conduct electronically and others that conduct ionically; both ionic and electronic conduction takes place in gases, and finally there are liquids which conduct electronically and others again that are conductive ionically.

WHAT IS AN ION?

In referring to ionic conduction, it may be well to digress a moment to discuss more fully the term ion, since there may be some misunderstanding if the definition of an ion is not clear. In accordance with the original use of the word "ion" by Faraday, an electron is an ion. In the Greek, "ion" means "goer" or "traveler," so Faraday, in thinking of the charge as carried by an atom, called the charged atoms, ions. Any ultimate carrier of an electric charge was called an ion.

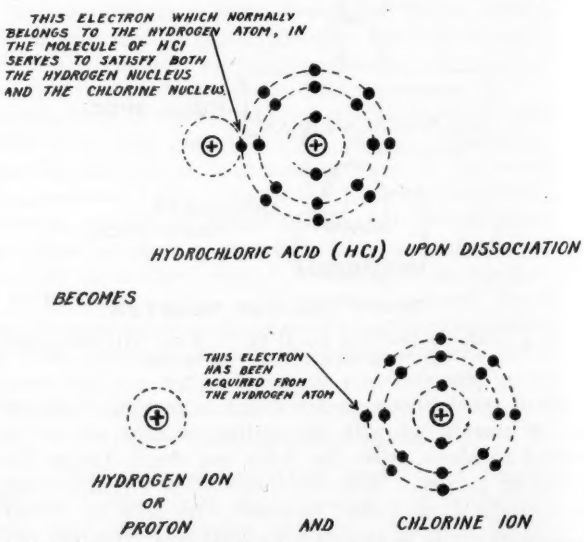

THIS ELECTRON WHICH NORMALLY BELONGS TO THE HYDROGEN ATOM, IN THE MOLECULE OF HCl SERVES TO SATISFY BOTH THE HYDROGEN NUCLEUS AND THE CHLORINE NUCLEUS
HYDROCHLORIC ACID (HCl) UPON DISSOCIATION
BECOMES
THIS ELECTRON HAS BEEN ACQUIRED FROM THE HYDROGEN ATOM
HYDROGEN ION OR PROTON
AND
CHLORINE ION

FIG. 2. AN ACID ALWAYS PRODUCES POSITIVELY CHARGED HYDROGEN IONS AS ONE PRODUCT OF DISSOCIATION

In the case of hydrochloric acid (HCl) shown above which is formed by the union of an atom of hydrogen with an atom of chlorine, upon dissociation the chlorine atom retains the single external electron which originally belonged to the hydrogen atom. This leaves of the latter, only the nucleus which is the proton.

Whether an electron, which is now known to be itself the ultimate electric charge, can be classified as an ion by this definition, depends upon how the word carrier is interpreted. If the word carrier is taken literally, an electron, which does not carry anything but itself, cannot be considered as an ion. If the original term "goer" is applied, however, an electron is as much

*All rights reserved.

[1] August 1 issue, page 825.

an ion as is a positively or negatively charged atom. In general, however, the term ion is applied only to an atom or molecule or group of molecules having more or less than the normal number of electrons. In these articles, an electron will not be referred to as an ion.

Ionic Conduction Involves Transport of Matter

The principal characteristic of ionic conduction is the movement or transport of matter. In the explanation of conduction through gases, it was seen that conduction of electricity was accompanied also by an actual movement of atoms of Helium gas. True, these atoms had lost an external electron but as has been

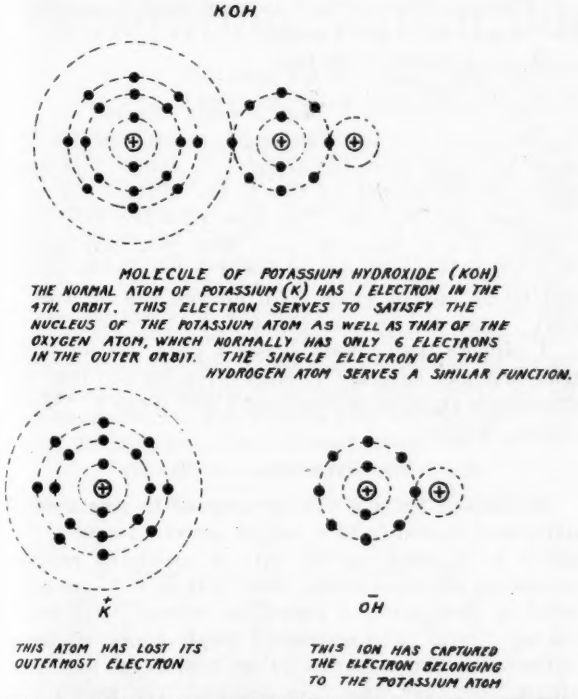

KOH
MOLECULE OF POTASSIUM HYDROXIDE (KOH)
THE NORMAL ATOM OF POTASSIUM (K) HAS 1 ELECTRON IN THE 4TH. ORBIT. THIS ELECTRON SERVES TO SATISFY THE NUCLEUS OF THE POTASSIUM ATOM AS WELL AS THAT OF THE OXYGEN ATOM, WHICH NORMALLY HAS ONLY 6 ELECTRONS IN THE OUTER ORBIT. THE SINGLE ELECTRON OF THE HYDROGEN ATOM SERVES A SIMILAR FUNCTION.
K+
OH−
THIS ATOM HAS LOST ITS OUTERMOST ELECTRON
THIS ION HAS CAPTURED THE ELECTRON BELONGING TO THE POTASSIUM ATOM

FIG. 3. POTASSIUM HYDROXIDE IS A BASE. IN DISSOCIATING IT YIELDS THE NEGATIVE ION OH.

The atom of oxygen which takes part in this union has only 6 electrons in its outer orbit where 8 would make a stable system. Hence it has an affinity for two electrons. For these reasons it combines readily with the potassium atom which has an electron to spare and with the hydrogen which also extends the loan of an electron. In dissociating, however, the oxygen and hydrogen atoms remain together, and retain the extra electron formerly belonging to the potassium atom. This gives the latter a positive charge and the OH ion a negative charge.

explained[2] the loss of an external electron does not fundamentally alter the atom.

This characteristic is more marked in conduction through liquids than it is in conduction through gases. In many liquids, dissociation occurs, that is, the molecules of such liquids or salts in solution are broken up into their constituent atoms or molecules. An example of this is had when sodium chloride (common salt) is dissolved in water.

Sodium chloride, NaCl, it will be recalled, is formed by the combination of the electropositive atom of sodium, Na having one excess electron, with the electronegative atom of Chlorine, Cl which lacks an electron. When this salt is dissolved in water, some of its molecules separate into two parts, one of which has the nucleus of the sodium atom and the other that of the chlorine atom. The number of external electrons around each of these nuclei is, however, not that of the normal atom. In the process of separating, the chlorine atom has failed to return the external electron which it borrowed from the sodium atom when it combined with the latter to form a molecule of salt. These systems, therefore, are not chlorine nor sodium atoms. They are ions and carry negative and positive charges respectively.

Molecular Systems Have Three Classifications

Such separation or dissociation of molecules is due not to collision as was the case in ionization of gases but is the result of the attractive influence of neighboring molecules of water. In other words, in the case of a salt solution of this kind, ions are formed spontaneously without the aid of an external electric field. This naturally simplifies the process of conduction materially.

Groups of atoms which will dissociate in this way may be classified under three headings, i. e., as acids, bases or salts. Acids are those systems which always give as one product of the dissociation, positively charged ions which are actually the nuclei of hydrogen

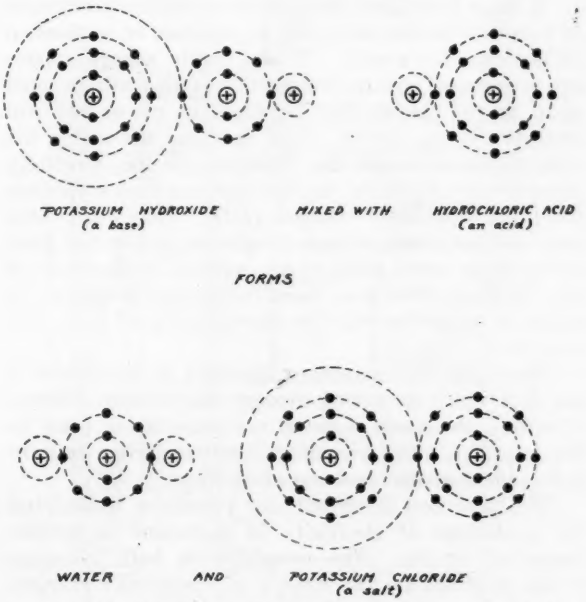


FIG. 4. A SALT IS FORMED BY MIXING AN ACID AND A BASE

Here, potassium hydroxide is mixed with hydrochloric acid. The hydrogen atom of the acid combines with the OH part of the KOH atom, forming water. The potassium atom combines with the chlorine atom to form a molecule of potassium chloride (KCl) which is a salt.

atoms, in other words, protons. They are spoken of, ordinarily, as hydrogen ions. Hydrochloric acid, HCl, is an example of this classification, since when it dissociates, the chlorine atom which is normally electronegative, retains the single external electron from the hydrogen atom, leaving of the latter only the nucleus. It may be of interest to point out here, that this is one of the very few instances where the proton will be found to exist alone.

Bases, are those systems which in dissociation, yield negative ions, OH which are formed of one atom of

[2]June 15 issue, page 678.

oxygen and one of hydrogen but have retained one external electron from the group with which they were formerly associated. An example is potassium hydroxide, KOH, in which the OH retains the excess electron formerly held by the potassium (K) atom.

The third group of systems which dissociate to produce ions, are the salts which are formed by mixing an acid with a base. When this is done, the positive and negative ions, H and OH, combine to form water, H_2O, as often as they meet and the other ions, when they meet, form molecules of salt. Suppose we mix potassium hydroxide KOH which is a base with hydrochloric acid, HCl. The positive ion, H, of the acid combines with the negative ion, OH, of the base to form water H_2O, while the potassium and chlorine ions combine to form molecules of potassium chloride KCl. In chemical language the reaction is

$$KOH + HCl = H_2O + KCl$$

Thus it is seen that the electron not only governs electrical phenomena but also chemical phenomena. The chemist today explains his reactions in terms developed by the electrophysicist.

Theory of Electrolytic Conduction

It must be evident that this spontaneous production of ions in solutions makes the explanation of conduction in liquids quite simple. If electrically charged plates are introduced into an electrolyte, the ions will be acted upon by the electric field between the plates and will be drawn to the plates. Upon reaching the plates, the negative ions release an electron to the positively charged plate while the positive ions acquire an electron from the negatively charged plate. Thus, they once more become normal atomic structures and in this form either cling to the plate or are released in the form of gas bubbles. We have here the actual transport of atoms or molecules which is characteristic of ionic conduction.

Sometimes, the substance liberated at the plates is not that which is carried through the solution because of certain secondary chemical reactions taking place in the solutions, such secondary reactions being entirely independent of the electrical phenomena.

We have now described the principles underlying the conduction of electricity in gases and in certain classes of liquids. The principles in both instances it will be noted are the same, i. e., electrically charged particles are acted upon by an electric field which cause them to move to the pole of opposite polarity where they serve to neutralize the charge on the plates.

Energy Relations

Before taking up the question of conduction in solids in the next article we will consider briefly the energy relations involved in gaseous and liquid conduction. When two plates are provided with opposite charges, the electric field resulting represents a certain amount of potential energy. In gaseous conduction, this field acts upon the ions, causing them to move and acquire kinetic energy at the expenditure of the potential energy of the field. When reaching the plate, the kinetic energy of the ions is imparted to the molecular systems of which the plate is made, manifesting itself as heat.

In electrolytic conduction, the dissipation of energy is somewhat different. The energy of the field is spent first in moving the ions against the viscous forces of the liquid which results in heating and second, in detaching or attaching ions at the electrodes in dissociation, and recombination of the electrolyte.

Watt - Wot?

By D. O. Woodbury

BILL HEAVY, fireroom attendant, and his chum from the wharves leaned obliquely against opposite sides of a beer barrel in Cheapside.

"'Enery," Bill remarked, looking owlishly around at his companion, "wot's a watt?"

Henry grunted in his beer.

"Wot's a *wot?*"

"Yep; wot's a watt? Wot *is* watts, 'Enery?"

The film of beer over the longshoreman's mental faculties rendered them too sluggish to follow this deep puzzle, but his ire was not slow to rise to the occasion.

"Look 'ere, William. You says, 'Wot is a wot?' and I says, 'Wot?' nacherly; and then you says again, 'Wot's a *wot*'—you damn parrot, I just enjoy to punch that lovely face of yours. I'll fill you full of wots, I will!" And the two set about their daily row.

I suppose that a watt causes a good deal of daily grief first and last, and it must often happen that the man who is expected to know wot's wot, doesn't. "Wot's a watt, 'Enery?"

Have You Ever Been an 'Enery?

An ampere times a volt is supposed to give a watt, and a watt is said to be a unit of power. Power is the ability to do work, or the rate of supplying energy. Generators are rated in kilowatts, that is, they are compared by their rates of generating energy. But when you say "rate," you necessarily imply a unit of time. In the other common terms we are used to, we use "per minute" or "per week" (sometimes "per month" if we are on salary). With the watt, there is no per anything, though we are told that it is a rate of doing electrical work. Volts times amps does not say anything about seconds or minutes, though they give power. Wot, then, is a watt, 'Enery?

In the text books, there is an ancient analogy which likens electrical conditions to hydraulic phenomena. The pressure behind a hose nozzle is said to represent the voltage in a circuit, while the quantity of water coming out stands for the current in amperes. This is all very well, except that when you speak of "quantity" you imply barrels or gallons or glasses per minute. Time comes in here. But from experience you know well enough that it doesn't take a minute or a second or any particular length of time to measure an ampere. It is flowing all the time, as an ammeter will tell you if you put it in the circuit and look at it. Evidently there is a discrepancy.

The rub comes in the conception of the unit of current—the ampere itself. This unit really means a quantity *rate;* what you actually mean when you say "ampere" is a "coulomb"—a fussy unit that nobody likes to mention and consequently drops in favor of its instantaneous effect, the ampere.

Now, if you think of the ampere as so many gobs of electricity *per second,* then, when you come to watts, you have the time element already included and no trouble will be encountered.

The customer will say: "Now, a man can produce a tenth of a horsepower. How much will it cost per hour to reproduce this by electricity at 2 cents per kilowatt-hour?"

("Now, do you know wot a watt is, 'Enery?")

A tenth of a horsepower is easily found to be a working rate of 55 ft-lb. per sec.—a man with such capabilities could raise 55 lb. one foot in one second. Now, the text book says: 746 watts equal one horsepower. Reduce it and you get one watt equals 0.74 ft-lb. per sec.

Thus the machine must supply energy at the rate of 55/0.74 or practically 75 watts. Allowing for efficiency and extra capacity necessary in a motor for such a job, you tell the customer that a 150-watt motor would do it. At 2 cents a kilowatt-hour, therefore, this workman could be replaced by electricity at an energy expense of three-tenths of a cent an hour!

"That's wot a watt is, 'Enery."

Generating Station Bus and Switch Structures

ISOLATED PHASE ARRANGEMENT, GAS-PROOF HOUSING, USE OF FAULT BUS, CONCRETE CELLS ARE PREDOMINANT FEATURES OF MODERN BUS CONSTRUCTION

GENERATING STATIONS having an effective ultimate capacity of 200,000 kw. or more are now being constructed, in the majority of cases, with the isolated phase bus arrangement. Of 24 stations covered recently by a report issued by the Electrical Apparatus Committee of the National Electric Light Association, 12 are designed for an ultimate capacity of not less than 200,000 kw. and, of these, 11 have isolated phase bus layouts. The one exception is a station in which the principal switching is done at high voltage on an outdoor structure. For stations with ultimate capacities below 200,000 kw., the adjacent phase arrangement

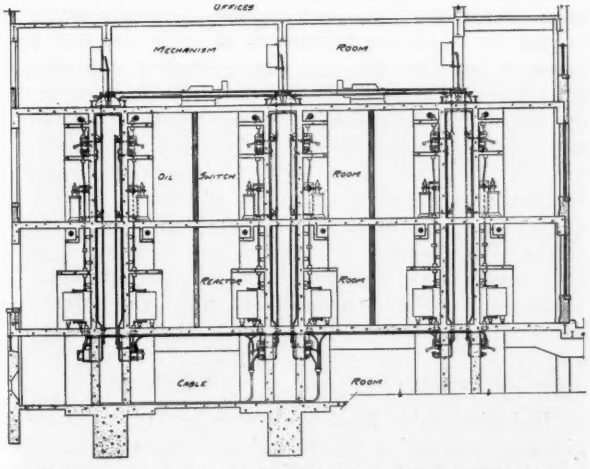


FIG. 1. TYPICAL HORIZONTAL ISOLATED PHASE ARRANGEMENT. CRAWFORD AVE. STATION, CHICAGO

seems to find general favor. In all but four of the stations of less than 200,000 kw. ultimate capacity covered by the report, the adjacent phase arrangement has been employed.

For large stations, it seems to be general opinion, although not unanimous, that a greater degree of protection can be obtained under the isolated phase arrangement than is possible with adjacent phase grouping. Under the isolated phase classification, the present tendency seems to indicate preference for vertical separation over horizontal separation.

Increasing attention is being given to preventing the spread of smoke or conducting vapor from a local source of trouble to other equipment not involved in

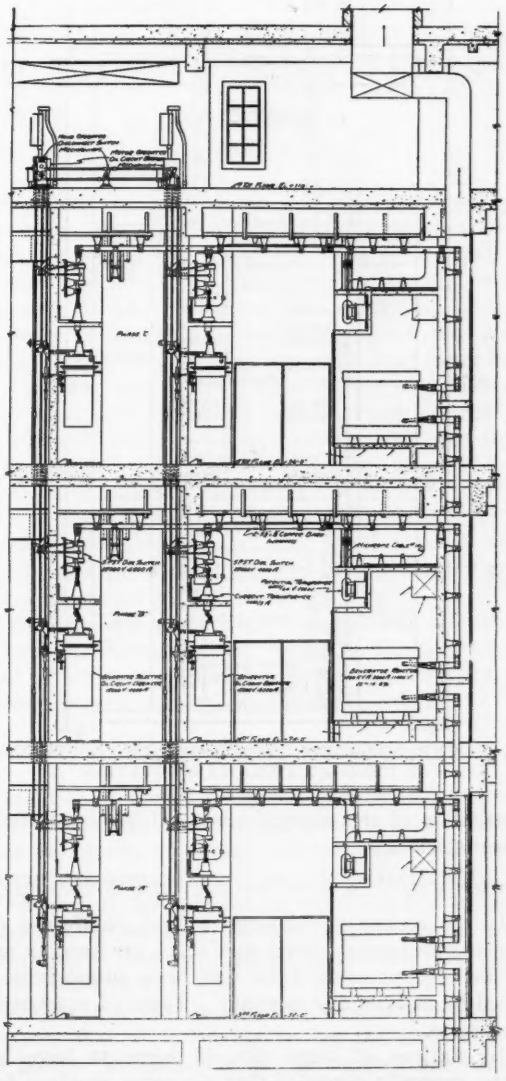


FIG. 2. AN EXAMPLE OF THE VERTICAL ISOLATED PHASE SYSTEM. EAST RIVER STATION, NEW YORK

the trouble by using equipment of gas-proof construction.

Another feature that is being used to a great extent is the fault bus. The use of a fault bus in an isolated phase switch-house makes possible the selective clearing of buses involved in trouble by a very simple relaying system.

Application of continuous insulation to bus bars which may now be accomplished either in the factory or in the field, is a means of guarding against the effect of conducting vapors and of preventing the

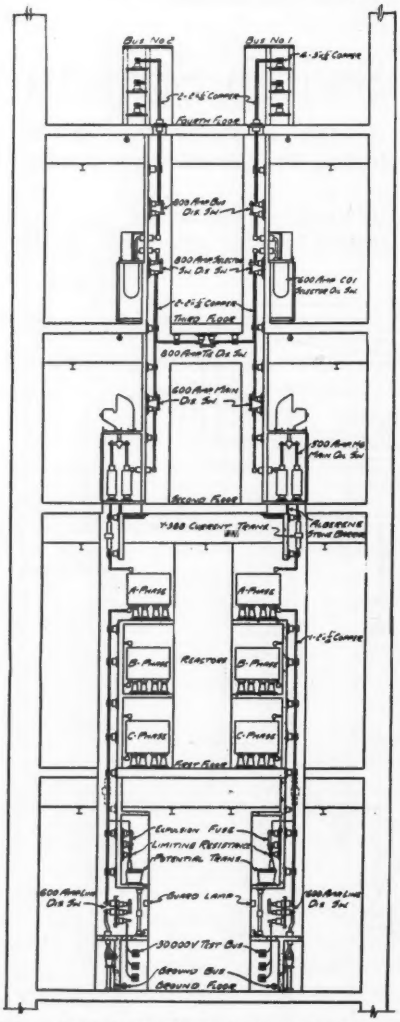


FIG. 3. THE ADJACENT SYSTEM OF BUS CONSTRUCTION AS USED AT DELAWARE STATION

propagation of arcs along the bus. It has been used in several stations.

Reenforced Concrete Used for Cell Construction

In the matter of cell construction, reenforced concrete predominates. Brick and stone are used in some stations and concrete brick has been successfully installed by at least one company. Types of construction are diverse.

In stations of large size, it seems to have been pretty generally conceded that the space required for a phase isolation layout is little, if any, more than required for the adjacent phase design and that there is an additional security afforded by the isolated phase plan which justifies any additional cost.

One company, however, which adopted the isolated phase design in one of its largest generating stations has more recently concluded that the advantage of this construction is not sufficient to justify it. In its newest stations, it has returned to the group phase design and intends to use it in another new station now being planned. It seems to be thought by this company that the important thing is to direct any arc to ground and that this can be accomplished with a group phase arrangement as readily as with isolated phase at less cost and with greater operating convenience. A few other companies are known to hold similar views.

Phase Isolation Alone Not Sufficient Protection

Since segregated phase stations were first constructed, it has become increasingly evident that phase isolation alone does not afford sufficient protection. A severe arc to ground or fire in one spot may readily create enough conducting vapor and smoke to spread rapidly and involve other circuits and buses at considerable distance. Gas-proof partitions, field bushings and continuously insulated bus-bars have, therefore, been so incorporated in the design of different stations as to prevent passage of gas: first, from phase to phase; second, from the circuits supplied by one unit to those supplied by any other unit; third, from equipment connected to one bus to equipment connected to another bus; and fourth, from circuit breakers for other apparatus to their associated disconnecting switches. The term "fault bus" has been applied to the copper connection by which the framework of apparatus and the bases of bus bar supports are grounded, and where the current flowing in these drainage lines is made to operate relays and assist in clearing trouble by opening circuit breakers, starting exhaust fans or sounding alarms. It is relatively easy to place current transformers in the various branches of such a fault bus and connect up plain overcurrent and multi-contact relays in the secondary obtained by which any group of breakers may be tripped or any other automatic operation performed immediately upon the establishment of fault current.

Induced Currents in Fault Buses

In laying out a fault bus system, attention must be given to preventing shunt drainage paths of too low impedance through the building steel. Some companies have made an effort to avoid any contact whatsoever between inserts in concrete and the reënforcing bars and have been able to get practically 100 per cent of the fault current to flow through the fault buses. Other companies have paid little attention to insulating equipment bases from building steel but have relied on getting correct operation by using current transformer ratios and relays which will function if only a small part, 10 to 25 per cent, of the fault current passes through these drainage buses. There is as yet too little operating experience to indicate whether this latter system will work out satisfactorily.

Some trouble has been experienced due to induced current being set up in fault buses which quite closely

parallel the main buses. It is evident that if such parallels exist there must be no closed loops either completely in the fault bus itself or partially through building steel.

In commenting on isolated phase station design, the General Electric Co. calls attention to the fact that to achieve the maximum protection with the isolated phase system, the bus arrangement, bus insulation, relaying of the incoming and outgoing circuits, fault bus system and the design of building must all be considered as a single all-inclusive problem. To lose sight of one point and its relation to the other factors may completely destroy the effectiveness of that point. According to this company's statement in the report, with the fault bus it is possible to obtain a degree of protection for the circuits in the isolated portion of the switch-house, not otherwise possible except by considerably complicating the relay system. The proper operation of the fault bus requires that current follow the prescribed path to ground rather than taking a path into the building steel. Experience has proved that this parallel path to ground through the building steel is of unsuspected low impedance and that the effectiveness of the fault bus is greatly impaired by such stray paths.

In the statement by the Westinghouse Electric & Manufacturing Company, included in the report, reference is made to the use of steel cubicles in place of concrete inner walls forming the breaker cells. In large substations such steel cubicles have actually been used in isolated phase design. This type of construction provides a complete metal enclosing structure for all elements of the circuit, providing a low-resistance path for the double current. At the same time, application of the fault bus to a steel-enclosed structure can be made readily so as to obtain the maximum benefit from this type of construction. Another advantage of metal-enclosed construction is that it permits the purchase of equipment as completely assembled in the factory as possible, thus reducing installation time and cost in the field materially.

Circuit breakers may be mounted on conventional type trucks with horizontal draw-out disconnecting contact or of the vertical lift-up type with a portable lifting device for handling individual pole units.

Coal and Ash Handling in Small Boiler House

ECONOMIES OBTAINED IN THE HANDLING OF COAL AND ASH DEPEND ON ADAPTATION OF MODERN EQUIPMENT. BY R. H. BEAUMONT, JR.

MUCH ATTENTION has been given to the handling of coal and ashes in central stations, but what of the small power house in which 10,000 tons of coal or less are consumed per year?

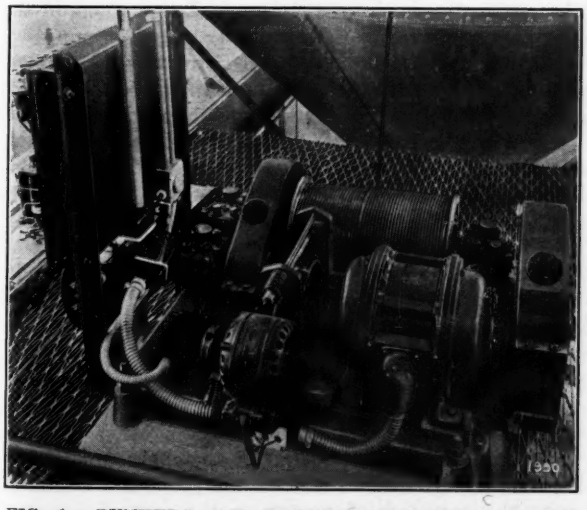


FIG. 1. BUNKERS AND WINDING MACHINE ARE SUPPORTED INDEPENDENTLY OF THE BUILDING ON FOUR COLUMNS

But a few years ago it was quite customary to install a number of small boilers from 150 to 250 hp., often hand fired. No basement was provided, the ashes being raked out on the boiler room floor, shoveled into barrows and dumped out the back door on the ground.

Usually, coal was shoveled by hand from cars through windows and onto the boiler room floor in front of the boilers, then reshoveled by hand into the boiler. The result was some steam and strong firemen. No one knew how much coal was burned except the purchasing agent and he knew only what he had paid for the coal, not how much was burned. Cost of handling the coal and ashes was given little attention. Mechanical means of handling, particularly the coal, was a difficult problem. Run of mine coal or at least large lumps of coal were used, which required large size units and, since the boilers were small and numerous, the coal had to be distributed over a comparatively long distance.

Occasionally an enterprising plant would install some sort of handling machinery but heavy expenditure did not seem warranted, consequently inadequate machinery was installed with the result that numerous shut downs and delays occurred so that the net result was often on the wrong side of the ledger.

With the advent of modern boilers and stokers, the picture is changed entirely and now the question, instead of whether to install coal and ash handling machinery, is what type of machinery to install.

LARGE BOILERS FACILITATE MACHINE HANDLING

In place of a long low boiler house with many small units, we now have a few rather high units. Ground space has become valuable; coal costs more; labor is expensive and temperamental and the neighbors will call the city hall if the least haze is coming out of the stack. Instead of having to pay to have the ashes hauled away, a neat profit may be obtained if the ashes are easily loaded into trucks.

Modern coal and ash handling machinery is as different from that of 10 yr. ago as are the modern stoker and boiler. It should be simple, rugged, moderate in price and, most important of all, it should be reliable. It must be almost entirely automatic so that not more

than one man, working 8 hr. a day, can handle all the coal and ashes.

Coal and ash handling requirements in the small boiler house are about the same as in a central station and are, relatively, just as important.

Methods Not to Be Recommended

Most of the large central stations have adopted modern coal and ash handling machinery because most central stations are designed by consulting engineers who specialize in such stations. Often the small boiler house is designed by a consulting engineer who may design only one boiler house in 5 or 10 yr. Design of the

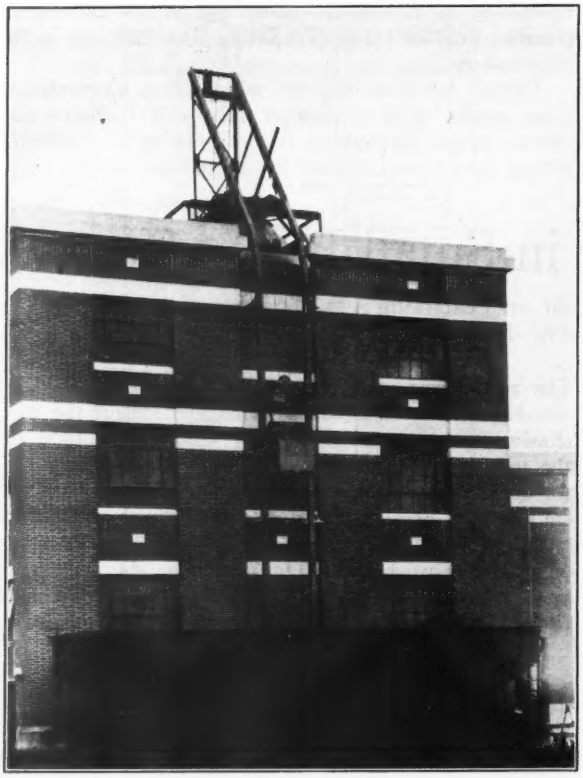


FIG. 2. SKIP HOIST ELEVATES COAL AND ASH TO OVERHEAD BUNKERS

boiler house may be allotted to a man who is essentially a civil engineer, an architect or what have we.

Then, again, the small boiler house is only a small end of a large contract on which a general contractor may be bidding. To get the contract, it is necessary for the general contractor to be low bidder. He will specify a modern boiler and stoker and then add one paragraph saying that "Coal and ash handling machinery will be included."

After he gets the contract and has bought the boilers and stokers, which probably exceeded his estimate on them, he faces the decision as to type of coal and ash handling machinery. To make matters still worse, he may have designed his boiler house leaving an opening or two at random for the coal and ash handling machinery. Then the question, instead of "What is the proper machinery?" becomes "What kind of coal and ash handling machinery can I buy that will go into those openings and which I can buy with the limited amount of money available?" The result is that the man who has to operate the plant gets an unsatisfactory job.

If a period of 10 yr. or even 5 yr. maintenance is considered along with first cost, the best modern coal and ash handling equipment costs less than light, cheap, inadequate equipment.

Concentration and Durability Essential

In order to obtain all of the advantages of a coal and ash handling system, it is necessary to centralize it. An example, as shown in the illustration, might be called "super-central" coal and ash handling. Only one motor drive is used, placed in a convenient location. One skip hoist elevates the coal from railroad cars to the bunker and the same equipment elevates the ashes to a section of the same bunker.

When handling coal, the skip hoist works fully automatic and, when handling ashes, it works by push button, or semi-automatically. If it is desired to crush coal, a crusher is placed above the bunker. Coal is delivered to the boilers by a hand operated weigh larry; ashes being taken from the boilers by ash cars and delivered to the skip hoist. Coal is stored outdoors and reclaimed by cable drag scraper.

Coal and ash bunkers, skip hoist and all machinery are supported independently of the boiler house building.

Advantages of this system are: A bunker of this type, where all the coal and ashes are concentrated at one spot and supported on but four columns, is the most economical to build and the usual distributing conveyor is eliminated, thus reducing the cost. Because the machinery is reduced to a minimum and is of rugged design, maintenance cost is low. Elimination of the distributing conveyor reduces power consumption.

In case of a new boiler house, it may be of simplest type, consisting of four walls and a roof, so that building need not wait on bunker and machinery, or construction of building and bunker may take place simultaneously. The bunker may be blended with the building to give pleasing exterior appearance, may readily be added to existing boiler houses at comparatively low cost and future extensions to boiler house, turbine room and coal and ash handling system may easily be made. No overhead bunkers obstruct light and ventilation. Machinery operates with minimum noise, which is especially desirable in built-up districts.

In modern industry, the three fundamental bases are: labor, material and money. Too often only the first two items are considered by the engineering mind. It must be remembered that when a problem is measured with the yardstick of economics, the cost of money is just as important as any of the others, and in the last analysis all industrial projects must show earnings or they cannot survive. The engineer must learn to use the dollar yardstick in measuring his problems and, in presenting reports to his executives, he must show that he has considered the financial return before his report will receive favorable consideration. He must learn to think in dollars as well as physical units of measurement and he will take his place in the sun only when he realizes that a proper balance sheet is just as important as an operating report showing good results.—Walter C. Beckjord.

Neglect of Compressed Air Equipment

By C. W. Stevens

GOING through the various departments, the boiler house, the blowing room, the power house, pumping station and other departments of a plant, it is doubtful whether the guide passes or calls attention to the air compressor plant. Only too often does he deliberately slide by the air plant, knowing too well what that place may look like. Contrast with the modern power house, with its bright equipment of generators and turbines, certainly throws the air plant into disrepute. Of all the necessary evils on the plant, the air pumps are about the "evilest."

It is well known that compressed air supply is as important as power or steam or water. When the compressors go down and there is no air, just as big a howl is raised as when the power goes off or the steam pressure drops. The plant is like a huge animal, with one of its systems, blood, respiratory or muscular, ceasing to function. It is out of business. Yet this center usually receives only the slightest care and attention, the smallest financial assistance and the greatest amount of abuse.

First, in the matter of using air, a workman will open wide an air valve on a hose and blow to his heart's content. Were the fluid steam or water, he would hesitate before opening his valve and then would give it only a turn or so, to use just the quantity of steam or water necessary for his job. He does not realize that air is the costliest of these fluids and usually the least plentiful.

When a steam plant is installed, all possible uses of steam are multiplied by a good safety factor to get the expected steam load, then a few extra boilers are bought besides those necessary for this load. With air, however, the load is usually under-estimated, the minimum capacity installed. Then, when the workmen find how useful air is for a multitude of jobs, even for the cleaning of their clothes, instead of using a brush, the available air soon becomes inadequate, so the air supply continually hangs on a string.

Then follows a schedule for various departments being "on the air". Certain departments have to wait until others have had their fill. This results in plant delays and the air plant gets the blame. Seldom are investigations made thorough enough to catch those who waste the air. Not uncommonly plants have to enlarge their air capacity soon after operation is started, so many new uses having been found for compressed air.

One reason for the air plant receiving so little consideration is that it is only recently that air compressors have been installed with a view of giving them an appearance comparable with the rest of the modern power house. The tendency toward centralized air plants is conducive to good looking installations, with all the embellishments, such as brass rails, polished parts and neat switchboards. Junky looking outfits are things of the past.

In going through one plant which had three large compressors running, the lack of care and attention given them was lamentable. In the first place, they were installed in a corner of a large building that was used for a general shop, combining the structural, machine, boiler, tin and other departments. Such places always have a lot of parts, castings, structural iron, plate, etc., lying around and the air plant became involved in the general mess. Originally, I believe, the place was kept in good order but it fell a victim to environment. To have enclosed it or to have placed the compressors and equipment in a separate room or building would have increased the neatness and efficiency of the plant tremendously. Good air compressing machinery makes just as attractive an appearance as engines, turbines and generators in a power house.

While looking the plant over, I unconsciously formulated a set of rules that would have resurrected the compressed air equipment, thus:

1. Compressors, receivers, piping should be painted.
2. Oil cups, grease cups, oil pumps, oiling piping (all brass work) should be cleaned and polished.
3. Accumulation of dirt, dust and grime should be wiped off piping, tanks and valves.
4. Floors should be kept free from paper, rags, oily waste, as well as oil, water and accumulated dirt.
5. Receptacles should be supplied for rubbish and for clean and oily waste.
6. The various grades of oil should be kept in uniform tanks, painted neatly and plainly marked. These tanks should have pumps supplied separately, with drains and pans to minimize loss and slopping of oil. An oil filter would save oil.
7. All tools and small parts should be neatly put away in their proper places, on shelves in a cabinet or storeroom, or hung up for ready use. Larger spare parts should be kept away from the compressors, in a separate room if possible, but arranged for convenience as well as cleanliness. They should not be exposed to unnecessary corrosion or possible breakage.
8. Old parts, valves, bearings, etc., should be removed, immediately upon completion of the repair job, from the premises to the plant scrap yard.
9. All gages and instruments should be in good working order and well taken care of.
10. Proper guards should be around flywheels, belts and other moving parts, to insure safety.
11. Pride should be instilled into the men working about the place; everybody should conscientiously put forth all effort toward maintaining cleanliness.

Increased efficiency follows neatness. Cleanliness inspires the men. There is no reason why the air plant should not be as inviting to visitors as the power house.

Another item that renders the average compressor plant hideous is the racket made by reciprocating compressors. One would be afraid to approach some machines, fearing they would fly apart. Most of this noise is correctible. Loose pins, bolts, bearings and crossheads, where motion reverses quickly, develop knocks readily. If not soon corrected, these magnify in a short time, making a great pounding.

Now that compressed air has become such a vital part of the plant, with the increasing uses that are found for it continuously, the air plant ranks along with the steam and electric plants and should receive the same respect. When the operators take personal interest in the equipment, keeping it clean and attractive, the management is more likely to take interest in it and become more liberal in the expenditure for its upkeep.

Kelvinator Corp. Installs New Boiler Plant

TO SUPPLY steam and compressed air to the new factory buildings of Kelvinator Corp., Detroit, Mich., a boiler house has recently been erected, the interior of which is shown in Fig. 1. Two Heine V-type

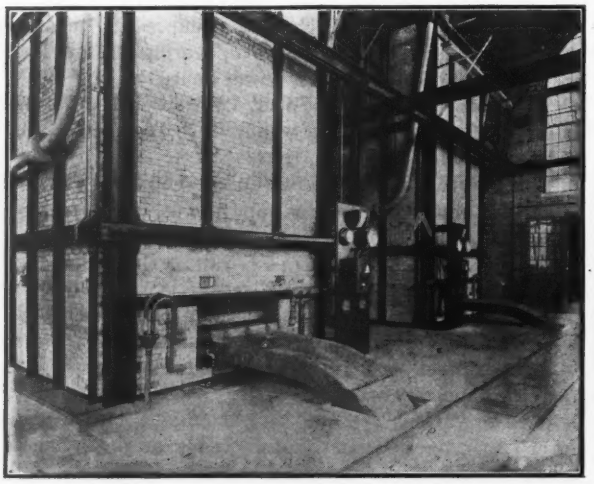


FIG. 1. EACH BOILER UNIT, TOGETHER WITH THE UNIT PULVERIZER SERVING IT, IS CONTROLLED FROM AN INSTRUMENT BOARD

FIG. 2. LOCATED IN THE BOILER ROOM BASEMENT, A SWING-HAMMER TYPE COAL PULVERIZER OF 4000 LB. AN HOUR CAPACITY SERVES EACH FURNACE

boilers, of 5040 sq. ft. heating surface each, generate steam at 225 lb. gage pressure for heating and process work only. Superheaters are not installed. Boilers operate, under usual conditions, at 160 to 170 per cent of rating.

Furnaces for these boilers are of the Liptak solid interlocking refractory type, with water-cooled arches and bridge-walls, which tie in with the circulating systems of the boilers.

Pulverized coal, with which these furnaces are fired, is supplied to each unit by a Strong-Scott Unipulvo, swing-hammer mill of 4000 lb. per hr. capacity. Pulverizing mills, one of which is shown in Fig. 2, are in the boiler room basement, the coal being blown from them to the burners through ducts running up through the floor.

Since all combustion air is supplied by a fan incorporated in each pulverizer and is blown into the furnace with the coal, no secondary air fans are installed and the layout of equipment is simple and compact.

Supply of fuel and air to each boiler furnace is controlled from the instrument board in front of each boiler, Fig. 1. Each board carries meters for steam and air flow, multipoint draft indicators and pressure gages measuring steam and feedwater pressures.

Built for an ultimate boiler capacity of 3000 b.hp., the building itself is 97 ft. by 80 ft., of yellow face brick with stone trim. It was designed by Smith, Hinchman & Grylls and is operated under the direction of Earl F. Roche, chief engineer.

Electrical Device May Permit Blind to Read Ordinary Print

ACCORDING TO a recent report, the whole field of literature may be opened to the blind by the invention of an electric device whereby printed letters are interpreted in the form of sounds. The device, called the "Visograph", is based upon the characteristics of the selenium cell.

A book is held in a mechanical holder and an electric ray about 0.001 in. in diameter is projected upon the page. The ray can be moved along at the will of the operator. The selenium cell is the main feature of the device. When the light-ray is on the white paper, an electric current flows through the apparatus, broadcasting a buzz through a radio loud speaker. When the ray strikes the black of the type, the current ceases, selenium being an insulator when in the dark and a conductor when exposed to light.

Upon the needle-ray depends a pantograph, similar to those used by architects and sculptors, geared so that a steel rod at its end travels four times the distance covered by the light ray. Under this rod are several aluminum strips, forming the ground on which the rod "writes."

The blind reader draws the pantograph over the strips and by alternating silence and buzz, feels out the shape of the letter, progressing then to the next, and so on to the end of the line.

JOINT RESEARCH COMMITTEE on Boiler Feedwater Studies of the A. S. M. E. has recently submitted report No. 10 of the Technical Sub-Committee on Bibliography. This contains a list of published material dealing with boiler feedwater, stream pollution, water treatment plants and the like. The report may be obtained from the Society at 29 W. 39th St., New York City.

Remodel Omaha Ice Plant to Meet New Demand

ELECTRICALLY DRIVEN COMPRESSORS, SHELL TYPE CONDENSERS AND DE-HUMIDIFIER ARE FEATURES OF OMAHA ICE & COLD STORAGE CO. PLANT. BY FRANK RAMSAY

PLANT NO. 1 OF THE Omaha Ice and Cold Storage Co., located at 5th and Leavenworth St., was remodeled the winter of 1925 and 1926. Because of the increase in demand for ice, the old plant had become inadequate in caring for the company's trade, so the old building was remodeled to accommodate new equipment. The work of installing the new equipment was entrusted to the York Allan Ice Machine Co.

Each of the three large ammonia compressors is driven by a 150-hp. General Electric synchronous motor mounted on the compressor shafts. The fields of the synchronous motors are excited by a 125-v. d.c. motor-generator.

An extra motor-generator unit is provided. The motors use 440-v. alternating current and are started by a push button mounted on each machine which does

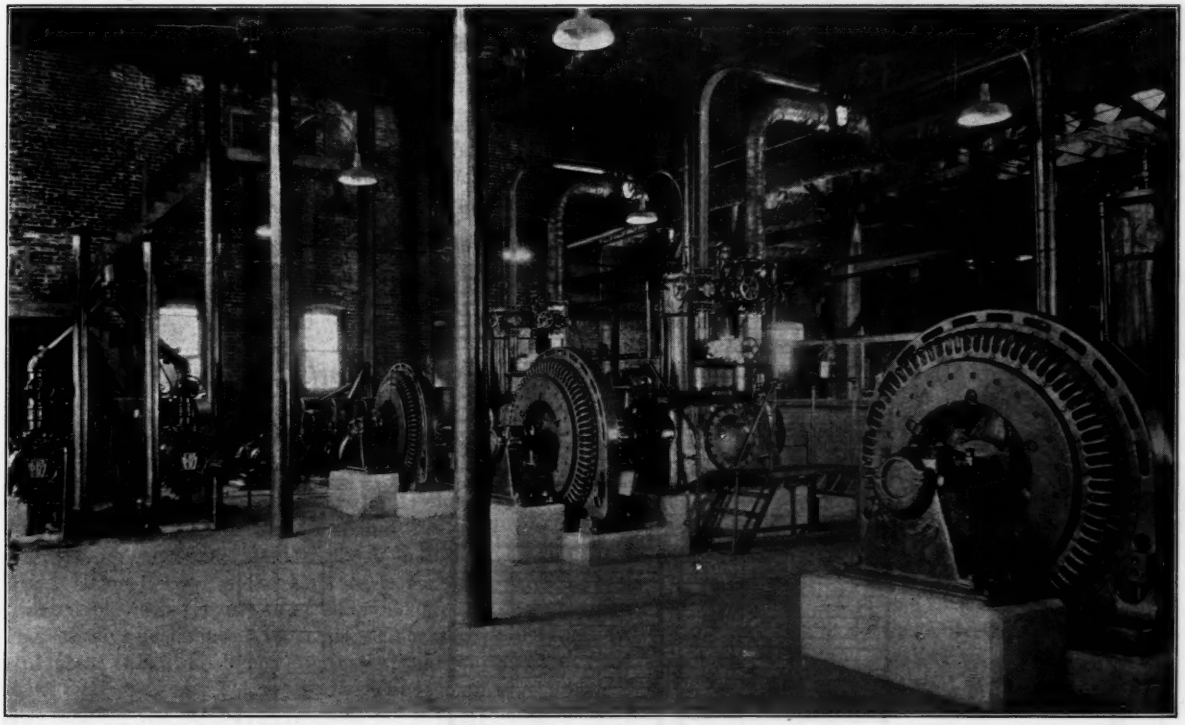


FIG. 1. GENERAL VIEW OF COMPRESSORS IN THE MACHINE ROOM

In the new engine room four ice machines are placed in line and connected to a main suction and discharge header. The hot gases flowing from the machines are allowed to pass to the condensers, which are of the shell and tube type, located just outside of the building and set over a concrete pit. The water used to cool the condensers is handled by one 400-g.p.m. and two 600-g.p.m. centrifugal pumps each directly connected to induction motors. These pumps are located in the engine room and are connected to a main discharge header that carries the water to a spray pond located on the roof of the engine room.

As the water runs off the roof, it is caught in a sump on the roof and allowed to flow by gravity over the condensers to a concrete basin below. In each tube of the condensers a small casting is placed which causes the water passing through the tubes to take a whirling motion and cling to the side of the tubes in place of dropping straight through without touching the tubes.

not necessitate the operator being near the switchboard when starting the machines. The 9 by 9-in. compressor is driven by a 50-hp. induction type motor using a Lenix belt drive, and is arranged so that it may be used on the main suction line, or on the water precooler, or as a pump-out unit. The relative arrangement of this equipment as well as that installed in the rest of the plant is shown in Fig. 2.

AIR DRIED IN DE-HUMIDIFIER

Air used to agitate the water in the cans is provided by a 15 by 10-in. air compressor of the horizontal double-acting type. A reserve air compressor is also provided. Each unit is driven by a 50-hp. induction motor using a Lenix belt drive. The air furnished by the compressor is cooled in a shell and tube condenser placed outside of the building. The air passes from this cooler to a de-humidifier where it is cooled to a temperature of 20 deg. F. and dried. Refrigeration for the

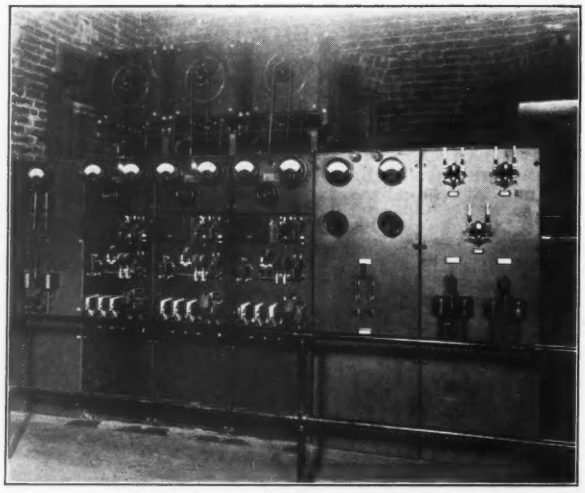


FIG. 3. SWITCHBOARD CONTROLLING ELECTRICAL EQUIPMENT

de-humidifier is supplied from a brine tank by a centrifugal pump. A reserve brine pump is provided.

Air, after being cooled and dried, passes through a reducing valve to latterals placed between the rows of cans on the tank floor. Hoses with a patented elbow on the end are used to make the connection on the ice cans.

Accumulator Traps Foreign Matter

An accumulator is placed in the suction line between the tanks and the ammonia compressors. This accumulator serves a dual purpose. It traps any liquid or foreign matter that may be in the suction line and also precools the liquid ammonia to the expansion valves, cooling the liquid to a temperature of 20 deg. F. before it enters the expansion coils.

A six-panel switchboard was furnished by the General Electric Co. On one panel is mounted the main switch and ammeter. Each synchronous motor has a separate panel on which are mounted the automatic throw-in switches, safety devices and a.c. and d.c. ammeters. Each has a hand regulated field rheostat to control the power factor.

A panel is provided for the motor generator set, on which is mounted a rheostat, a voltmeter, and an ammeter. Another panel is provided for the 9 by 9-in. ice machine, the two air compressors, the circuit breakers for the lights and the ice hoists.

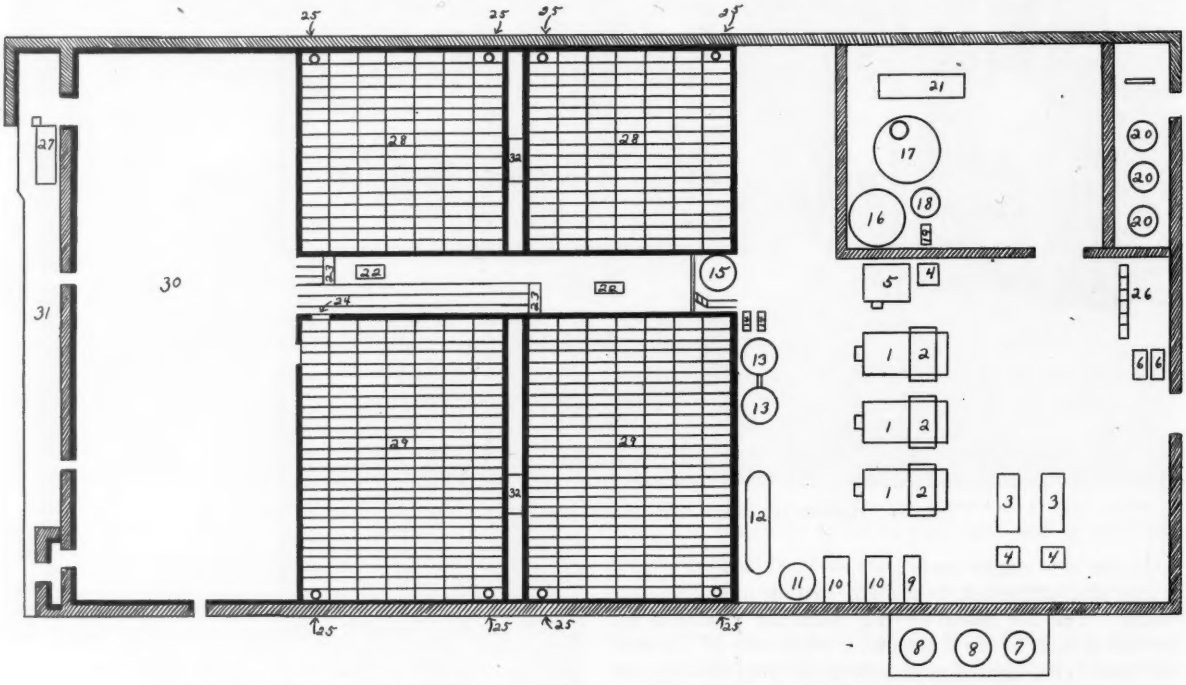


FIG. 2. FLOOR PLAN SHOWING ARRANGEMENT OF EQUIPMENT IN PLANT

1.—Three 12½ by 14 York vertical single acting double cylinder ammonia compressors.
2.—Three 150-hp. General Electric synchronous motors. 440-v., 120-kv-a., 164-r.p.m. direct connected.
3.—Two 15 by 10-in. Pennsylvania air compressors, horizontal, double acting, 275 r.p.m.
4.—Three 50-hp. General Electric induction type motors, 440-v., 1150-r.p.m.
5.—One 9 by 9-in. York, vertical single acting double cylinder ammonia compressor.
6.—Two 125-v. motor-generator sets.
7.—One shell and tube condenser on air compressor line.
8.—Two shell and tube condensers on ammonia line.
9.—One 400-g.p.m. Union centrifugal water pump directly connected to 12-hp. Westinghouse motor.
10.—Two 600-g.p.m. Dayton-Dowd centrifugal water pumps directly connected to 15-hp. General Electric motor.
11.—One ammonia oil trap.
12.—One ammonia receiver.
13.—One de-humidifier.
14.—Centrifugal brine pumps directly connected to 2-hp. motor supplying refrigeration to the de-humidifier.
15.—York ammonia accumulator in suction line.
16.—Filtered water precooler.
17.—International Filter Co. sedimentation tank for treating water supplied to freezing tanks.
18.—International Filter Co. sand and gravel filter.
19.—Two centrifugal pumps directly connected to 3-hp. motor supplying treated water to tank floor.
20.—Electric transformers, 13,200-v. to 440-v.
21.—Locomotive type boiler used for heating building.
22.—Thawing tanks.
23.—Can fillers.
24.—Centrifugal pump directly connected to 3-hp. motor supplying refrigeration to ice storage from brine tank.
25.—Vertical brine tank agitators.
26.—Six-panel switchboard.
27.—Uline ice scoring machine.
28.—Two 357-can ice tanks.
29.—Two 567-can ice tanks.
30.—2500-cake storage.
31.—Loading platform. Two Euclid electric hoists 1840 11½ by 22½ by 58 ice cans.

Each auxiliary motor is provided with an individual starting switch and safety devices. A purging machine is provided for removing the foul gases from the system.

Water Treated with Lime

City water is used for ice making and is treated with lime. All treated water is precooled in a reserve tank before being used. The tank floor consists of two large and two small tanks. The large tanks hold 567 ice cans each and the small tanks hold 357, making a total of 1848 cans. The tanks are arranged so the one crane will take care of two tanks—one large and one small. Cans are the standard 400-lb. cans with an air tube soldered on the side. Brine is agitated by two vertical agitators mounted on each tank.

Two electric, three-can ice hoists, are used to harvest the ice. Each hoist is provided with a three-can dump and can filler. The ice is cored with an electric driven core siphoning machine.

The storage room which has a capacity of 2500 cakes is cooled with brine furnished by a directly connected centrifugal pump.

This plant is flexible in its operation and may be operated to take care of the seasonal changes, thereby supplying the customer with newly harvested ice.

A scoring machine is provided to score and remove the white tops. The plant used an average of 47 kw-hr. per t. of ice and is capable of producing 185 t. daily.

Tidal Power Project in France

Rotary Converters Will Take Output of Direct Current Generators

PLANS ARE now being prepared for the erection of a large tidal power plant on the northwest coast of France. The project is described and discussed at considerable length by M. Louis Schwob in Le Genie Civil. The location chosen is the Baie de la Frenaye, Fig. 1, situated between the towns of St. Malo and St. Brieuc. This estuary is believed to be particularly suitable for a plant of this kind, being almost rectangular in shape, about 3 mi. long and 1½ mi. wide. The bottom is rocky, thus making the laying of foundations a comparatively simple matter; and the water, being clear and clean, will produce a minimum of abrasion of turbine vanes. The tides at this point of the English Channel vary from about 10 ft. at the time of so-called "dead water" to 44 ft., with a mean amplitude of 26 ft. In addition to these advantages, there are two river valleys running into the bay and these valleys (fortunately with very little population) will be flooded at the times when the tides are at their maximum and when, consequently, an excess of power can be generated. The water will be pumped to a height of 115 ft. above the main level of the bay and will provide a reserve supply of about 700,000,000 cu. ft. of water available for use at times of low tides or during the twice-daily occurrence of the change of tide. The plant will operate at "double effect"; that is to say, will be actuated by both incoming and outgoing water.

The dam across the mouth of the bay will be sufficiently long to allow of the placing of about 150 units, each consisting of a turbine and dynamo. But it has been found that the power developed does not increase

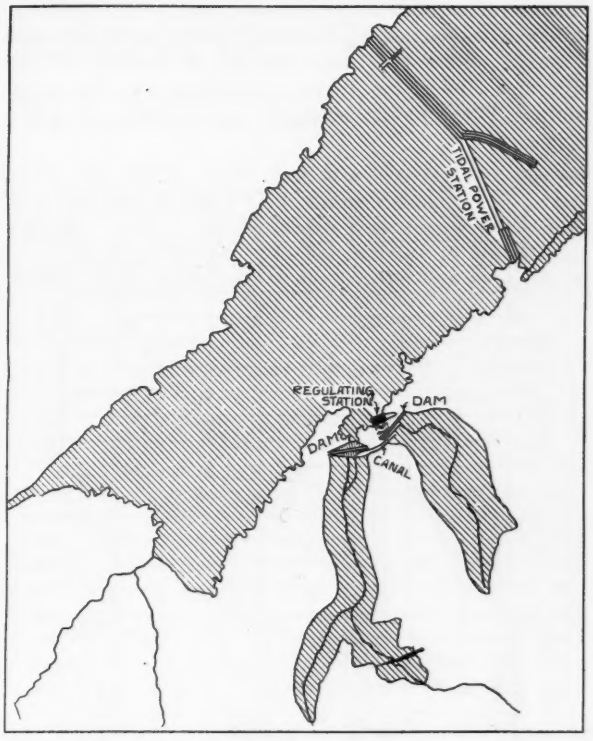


FIG. 1. BAY OF FRENAYE OFFERS TIDAL POWER OPPORTUNITY

in proportion to the number of units employed, so it has been decided to use 70 such units, one-half only of which will be installed at first.

With regard to the problem of getting the greatest efficiency of the turbines, it can be demonstrated that the speed must vary as the square root of the height of fall of the water, to get a constant efficiency. But in a tidal power plant the turbine speed cannot be constant, so it has been decided to use direct-current dynamos rather than alternators. The line will be connected with a number of steam power stations and, where necessary, converters will be employed.

The accompanying diagrams have been prepared by the Swiss Society Th. Bell and by the Alsatian Society of Mechanical Constructions, which have made a specialty of the study of high-speed turbines and variable voltage dynamos, respectively. Figure 2 gives the characteristics of the operation of turbines with tides of 3 to 26 ft. In this diagram N represents horsepower, n the

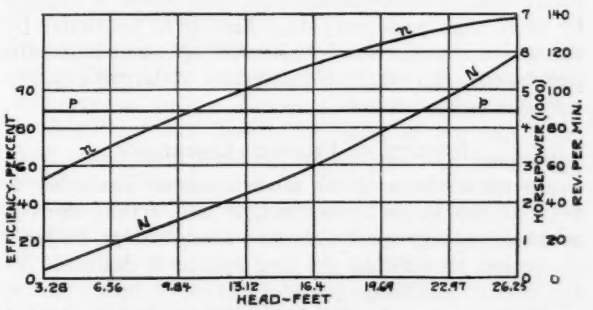


FIG. 2. POWER AND SPEED OF TURBINES VARIES WITH HEAD AVAILABLE

number of revolutions per minute, and p the efficiency, which, it will be noticed, remains constant at 84 per cent. Figure 3 gives the characteristics of working of the dynamos under the given conditions. V represents voltage, P the power developed in kilowatts and p the efficiency.

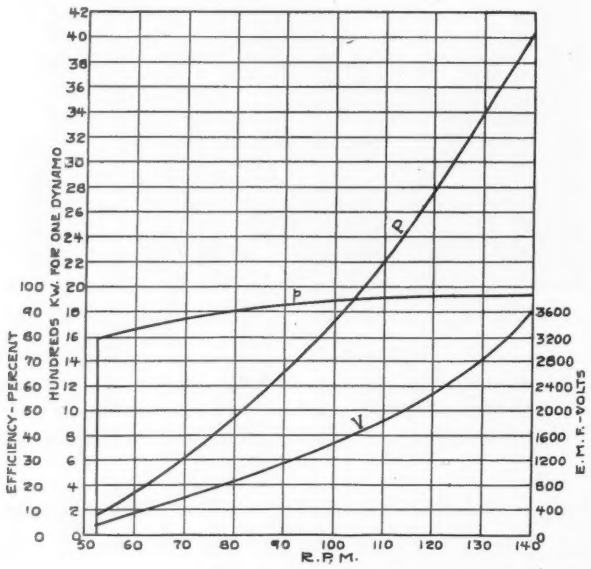


FIG. 3. VOLTAGE AND POWER OF GENERATORS VARIES WITH SPEED

For a group of 70 units, energy available in 24 hr. varies from 350,000 kw-hr. at 13 ft. head to 2,400,000 kw-hr. at 39 ft. head. When 35 units are used, the energy for 24 hr. at 13 ft. head is 250,000 kw-hr. and at 39 ft. head is 1,350,000 kw-hr. This head variation is the mean daily amplitude. It is estimated that about 20 per cent of the gross power developed will be required for operating the regulating works.

Trend in Station Plant Design

SPEAKING before the Institution of Civil Engineers, S. L. Pearce gave as the factors influencing such design: The use of large units, boilers to supply a 50,000-kw. turbine set, turbine-generators up to 100,000 kw.; higher pressures, up to 600 lb., as Mr. Pearce considered 1200 lb. unjustified except in special cases; higher temperatures, ranging up to 850 deg. F. in European practice; reheating, which introduces complication and increases initial costs and which is avoided by using high pressures; stage heating of feedwater by extraction steam; use of higher voltages and high-voltage generators; use of transformers of larger capacity and for higher voltages.

Results of Changed Conditions

In consequence of the above changes, less space is required for boiler houses and, if unit arrangement is adopted, piping can be shorter, though Alex Dow, in discussion, stated that the ring system is desirable for the sake of flexibility.

Higher pressures call for better joints but smaller piping can be used and the condensing system may be smaller because of less steam needed per kilowatt-hour and the extraction of steam for stage heating. Compounding of turbines is being tried and the vertical twin condenser seems to be practically standard.

High temperatures demand materials which will stand up and not corrode. Alloy steels give some promise of meeting the need but will involve higher cost.

Heating of Steam and Feedwater

Reheating requires extra boilers with complication in piping or, as now seems better, the use of high-pressure steam reheaters.

Stage feedwater heating means complication in heaters and piping, a rise in temperature of about 60 deg. per stage being found most economical. As this removes the need for auxiliary exhaust for heating, house service generating units are disappearing, auxiliaries being motor-driven from the main buses through step-down transformers.

High-voltage generators, to deliver at transmission voltage direct, save complication and cost but are less efficient, stator windings are weaker mechanically and may call for reactance in the windings to smother short circuits and damp out harmonics, which has been taken care of by the step-up transformers.

High voltage is easier to handle than large current because, with the latter, heating of contacts, eddy currents, skin effect on conductors and large magnetomotive forces are encountered. Also the heavy switch gear required for large currents is difficult to operate. Above 33 kw., it is now common to use outdoor switch stations.

Fabricated structures of steel are being used for large generator rotors on account of problems in shipment.

Banks of single-phase transformers are practically universal for large installations with 3-timber cores. The high-pressure side for step-up transformers is connected in star, with neutral grounded, and the low-pressure side in delta. This is done to cut down trouble from harmonics and surges in the system. For step-down transformers, the converse is preferable but, if not feasible, star-delta connection may be used with an artificial grounded neutral point on the delta side, or star-star connection with a delta-connected tertiary winding.

Forced circulation oil cooling is used for large units, with external air or water coolers.

Bulletin No. 47, "Union Scales of Wages and Hours of Labor" has just been released by, and may be secured free from, the Bureau of Labor Statistics, U. S. Department of Labor. This Bulletin includes reports for 862,308 trade union members employed at time rates in 66 leading cities. Among the trades considered are: bakers, brick layers, carpenters, plasterers, longshoremen, book and job printers, newspaper printers, bus drivers, and street railway motormen and conductors. Employes in the time work trades had an average full time of 45.2 hr. per week. The union trades as a whole experienced an increase of 260 per cent in the time wage rate per hour and a decrease of 7.6 per cent in the full time hours per week, between 1913 and 1927.

Novel Boiler Model Produces Dry Steam*

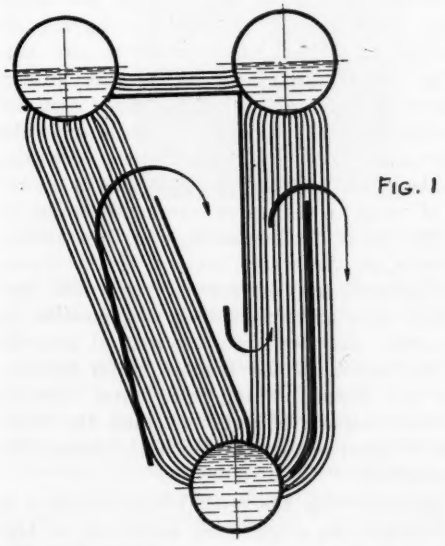
THREE YEARS OF EXPERIMENTAL WORK BY GERMAN FIRM BRINGS TO LIGHT NEW IDEAS FOR STEAM GENERATION. BY DR. BERNER

THERE IS A LIMIT in nearly all modern boilers above which the water content of the steam increases rapidly and suddenly. It has therefore been found necessary to attempt to raise the limit at which the water content increases, beyond the point of highest boiler firing capacity.

Consequently, Voelcker of the firm Keilmann & Voelcker, G. m. b. H., Bernburg i. Anhalt, Germany, has made a number of investigations in the circulation of water in a special experimental plant equipped with models of vertical-tube boilers. The more important investigations were made in the presence of the writer, Dr. Eng. Berner.

The models have a heating surface of 22 to 75 sq. ft.; their width is shortened and they correspond according to their elevation to boilers of 108 to 321 sq. ft. Furthermore, a few individual boiler tubes of standard size were included in the experiments. All experimental boilers were equipped with observation windows at the suitable points on the drums or chambers. The pressure was purposely kept between 15 lb. and 88 lb. absolute; since at these pressures the volume of steam is especially large, the activities could be observed much better. Heating was done with gas or oil. The evaporation, the water content of the steam and the direction of flow in the individual tubes were determined. During the three years of experimental work 16 models were built and nearly all of them were repeatedly changed and tested again.

In the first experiments the ascending tube bundle of the three-drum boiler was heated single-stage and from one side as usual (see Fig. 1). It was noticed that the output has a very strong influence on the circulation. The elevation of the pressure of the heated vertical tubes dropped with an increase in output and finally it was incapable of overcoming the elevation in pressure in the but little heated ascending tubes in the rear. The latter changed therefore into descending down-current tubes. Between the ascending tubes in the front and the descending tubes in the rear there were some tubes actually in an unstable circulating condition. They changed the direction of the current or flow as soon as the requirements were changed. This resulted in vibrations or oscillations which started at about 30 kg. per sq. m. per hr. (6.14450 lb. per sq. ft. per hr.) and continued into the ascending tubes. Exteriorly this was indicated by the fact that the steam no longer flowed regularly upward and that at times it



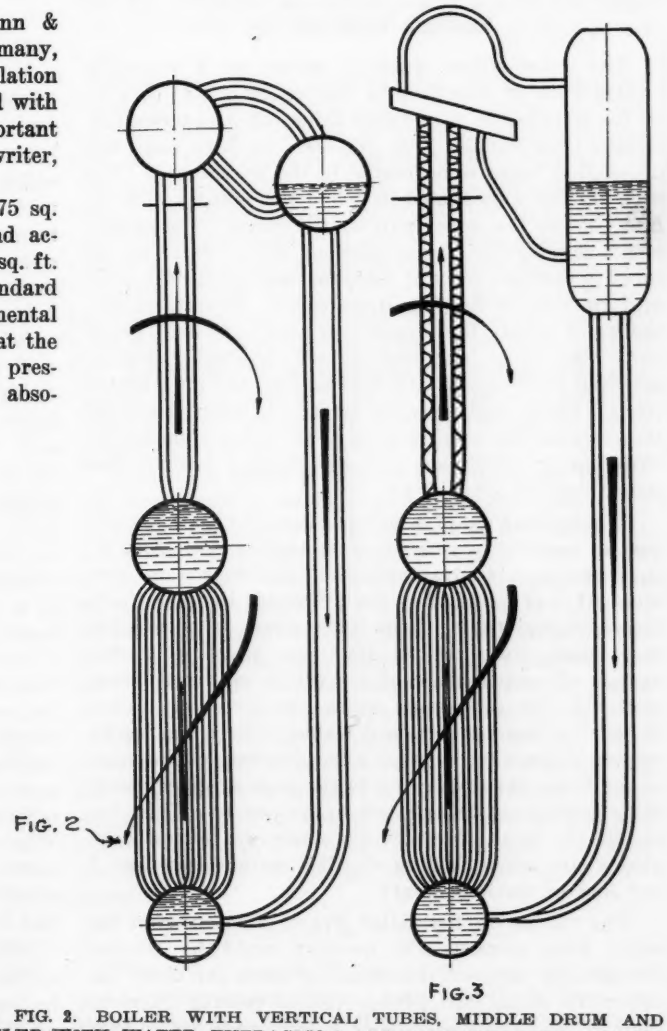


FIG. 1. CONVENTIONAL FORM OF 3-DRUM BOILER. FIG. 2. BOILER WITH VERTICAL TUBES, MIDDLE DRUM AND DESCENDING TUBES IN COLD SECTION. FIG. 3. BOILER WITH WATER EXTRACTION ARRANGEMENT USING SPIRAL SURFACES IN UPPER ASCENDING TUBES

*Abstracted and translated from the "Zeitschrift des Vereines deutscher Ingenieure."

flashed, as if it were returning, back into the lower drum.

These interruptions in the lower part of the ascending tube bundles are especially serious since here the speed of the steam and the water and therefore the cooling effect are at their lowest.

Tests with un-cleaned feed water showed also that the scale deposits in the lower tube ends were considerably greater than in the upper tube ends. Therefore the endangering of the heating surface by the additional arrest of heat transmission below is also greater than farther above.

Vertical Tube Boilers

The boiler either consisted merely of a vertically located even or smooth tube bundle, or it was divided by the installation of a middle drum into two oppositely located tube bundles (see Fig. 2). In both cases the descending tubes were located in the colder area. The even bundles were heated in two or three stages with the first pass at the upper part of the tubes. The experiments showed that the circulation of the water in the tubes located one back of the other was essentially more uniform than in the three-drum boiler. In spite of this, the water supply to a descending tube of a small cross-section no longer occurred not only through these descending tubes, but in part also through the little heated tubes. Under high evaporating output there appeared therefore similar conditions as in the three-drum boiler: vibration or oscillation and the flashing back of the steam into the lower drum.

Through the use of a middle drum, the upper bundle has an essentially smaller cross section (see Fig. 2) since one expects advantages from the lower water content. It was found that the difference in pressure in the individual tubes of the lower drum were now but very small, since the middle drum effects a certain amount of compensation. Even with a very small cross-section in the descending tubes, the direction of flow in the two bundles remained stable. There was no reversing of the water flow nor a flashing back of the steam in the lower drum, even up to the highest steam generating capacity of 185 kg. per sq. m. per hr. (37 lb. per sq. ft. per hr.). Thereby the steam was almost completely dry when feeding distilled water (less than 1 per cent of water content).

The raising in the boiler was so vigorous that the water level towards the exterior could be lowered through the non-heated descending tubes far below the upper rim of the rising tubes without causing interruptions in the circulation. With a decrease in water level the quantity of circulating water decreased and the steam was drier. If the water level was lowered to about the elevation of the middle drum, the water circulation ceased completely and superheated steam was produced. Such a strong reduction is of course not in question for operating and economical reasons. On the other hand, it is important to be able to decrease the circulating water in the boiler at will in order to increase the dryness of the steam. This is not possible without a middle drum, since then the circulation through the tubes which are the least heated in the ascending tube bundle, would short-circuit; there is then danger that too low a water level might occur in these tubes.

It is already known that the water content of the steam increases as the water surface in the upper drum decreases. During the tests the quality of the feed water had also a great influence on the drum. This was shown especially well with a boiler water containing salts. At a capacity of 50 kg. per. sq. m. per hr. (10.24085 lb. per sq. ft. per hr.) the steam was still very wet (10 per cent water content), when the drum was even half-filled. Only with a fairly empty drum could sufficiently dry steam be generated. Therefore, the rise of steam bubbles through the filling water of the drum makes steam extraction more difficult.

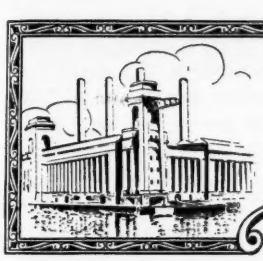
Extracting Water from Steam with Spiral Surfaces

In order to utilize the strong and consistent rise in the vertical-tube boiler having middle drums, for the extraction of the water from the steam, spiral surfaces which effect a spiral motion, were placed in the upper tube bundle (see Fig. 3), in order to give the steam a turning movement and thereby start the separation of steam and water inside the tubes. The experiments showed that the power of the raising steam in the boiler for the production of the strapping movement was sufficient at all times. It was found also that one could work only with circulating water, without filling the upper drum with water. Thereby the water in the upper rim of the ascending tubes was forced to the side while the steam passed up through the center of the tubes. As expected, the mixture having the greatest amount of water was forced to the tube walls by the spiral surfaces. With this process the upper drum is replaced with an inclined sectional chamber (see Fig. 3) which directs the circulating water to a collector located vertically above the descending tubes; while the steam from the chambers moves up and is separated of water in the upper part of the collector. The size of the water-heating surface in the collector has no influence on the water content of the steam; therefore the collector may be kept of very small proportions. With this arrangement it was possible, in spite of the small chamber cross section, to generate technically dry steam at the highest boiler outputs. When using non-cleaned water, the spiral surfaces showed a heavier deposit of sediment than the tubes, which is also of great advantage for heat transmission and operating safety.

The experiments with the models have resulted in valuable information on evaporating conditions at high boiler outputs and show how to overcome the difficulties which arise during high loads.

Electric cutting and welding of reënforcements to columns and beams, of extensions to columns and of beams and joists to columns, is being used in remodeling and enlarging the Rose Building, Cleveland, Ohio, from a six to a 10-story structure. The method avoids disturbance of tenants and neighbors, permits of cutting and joining all members of the structure in the field and reduces the wrecking of the old structure to a minimum.

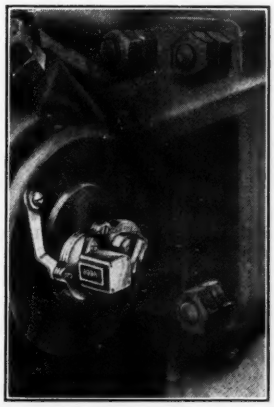
New piping required is also being installed with butt-welded joints for the larger sizes.



LETTERS DIRECT FROM THE PLANT

Stoker Movement Measures Coal Consumption

MOST INDUSTRIAL steam plants obtain their record of coal consumption from the number and net weights of cars of coal unloaded during a month. In some plants, when costs are figured, the coal in the hoppers and bunkers is gaged and used in obtaining greater accuracy in the coal consumed. For the cost department, or from an accounting angle, where a large number of cars of coal are consumed per month, this is a very good method, for the coal is paid for on this basis.



COUNTER RECORDS STROKES OF UNDERFEED STOKER

To the power plant engineer, however, whose water consumption is measured hourly and whose output is all upon an hourly basis, a monthly coal consumption figure is almost worthless, except to criticize him after the month's work is done. Car weights are useless to him. He has no means of watching his coal consumption, except indirectly through CO_2 recorders or other plant instruments.

Where boilers are fed by chain grate, underfeed, or other stokers, the coal consumption can be checked with fair accuracy, in any units of time desired, hourly or daily, by means of a simple revolution counter. The author has used this method on both the chain grate and underfeed types of stokers, with good results. Used in conjunction with other instruments, this method of estimating coal consumption was found to be useful in watching the hourly economy of operation and catching undue losses or troubles.

Volume of coal passed into the stoker is an actual measurement which must be converted into weight. Since the size of coal is practically uniform throughout the year, conversion factors can be made up that hold fairly well. These factors must be checked often, however, by taking actual samples, using a cubic foot measure or bucket and weighing definite volumes of the coal.

Underfeed stokers are fed by plungers or rams which have a definite volume; bore and stroke. A counter recording the number of times each ram charges coal into the furnace is fastened to the crankshaft or any convenient place to record the revolutions of this shaft. This hourly record multiplied by the number of ram strokes per revolution and by the displacement of each ram, times the weight factor, gives the coal consumption of this boiler. Of course, the ram cylinder may not fill up the same each time or some coal may come back into it as the ram returns, etc., but an average figure can be obtained after trial that will give desired relative results. These figures will certainly follow the flow meters and other instruments if everything is normal.

With chain grate stokers, the depth of the bed of coal is regulated by an adjustable guide extending along the width of the chain at the entrance of the coal on the stoker, or at the exit of the stoker hopper. The width of the coal bed is also fixed by the opening of the hopper, so that the area of the coal bed section is fairly constant. Hence, it is only necessary to measure the speed of the chain. The same type of counter can be used for the chain stoker and any number of places selected for its location. The actual application of a counter to any stoker is merely a local problem. The essential point is to get the counter to record correct amounts, that is, great care must be exercised in converting the speeds of the various elements so that the counter will not give erroneous stoker speeds. The general formula for calculation of coal consumption then becomes:

$$\text{Coal consumption} = T \times W \times D \times C$$

Where T = travel of grate in feet per hour which is the number of strokes on counter per hour times the feet of chain travel per stroke.

W = width of stoker in feet
D = depth of fuel bed in feet
C = pounds of coal per cu. ft.

Regular hourly readings taken on such an instrument at the same time as other instruments of the boiler house are read, should certainly be a guide to the foreman or firemen. A recording counter giving a chart record similar to the flow meters or other instruments would be of even greater value in that the dips and peaks would clearly point out changes in load.

Dayton, Ohio. C. W. STEVENS.

Soil Pipes Anchor Stack Guy-Lines

WHEN OUR NEW boiler was being erected, it was necessary to provide two new anchors for the stack guy-wires. This was done by utilizing two lengths of extra heavy soil pipe that had formerly been used for an automatic sprinkler system.

These pipes are each 5 in. inside diameter, 7 in. outside diameter and 12 ft. long. To set them, holes were dug in the ground about 3 ft. wide by 4 ft. long and 5 ft. deep. The pipes were placed centrally in the holes at a proper angle with the stack and braced in place. The holes were then filled up about 3 ft. with concrete. When that had set the balance of the

SOIL PIPE FILLED AND SURROUNDED BY CONCRETE FORMS SUBSTANTIAL ANCHOR FOR GUY-LINE

holes were filled with earth. The insides of the pipes were also filled with concrete. The guy-wires were fastened about 18 in. from the top as illustrated and a rigid anchor was secured.

Louisville, Ky. FRED E. BOND.

Belts Laced Properly

REFERRING to the short article under the above heading in the July 15 number of Power Plant Engineering, page 785, I see a few more or less serious objections to the type of lacing recommended by E. F. Jackson.

By punching the finishing holes along one of the edges as shown in the sketch, it is obvious that the belt will be weaker along that edge than elsewhere, consequently it will stretch more on that side than on the other side and the belt will run crooked. It is better to punch the finishing holes along a center line as is the usual practice.

Another objection to finishing the lacing on one side is that that side may begin to yield before the other side will. The stretching on the weak side will be more pronounced than where the lacing is begun in the center with a uniform condition on both sides.

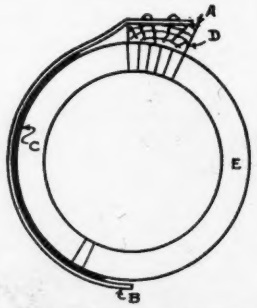
Usual practice when lacing belts is to have an odd number of holes instead of an even number as shown in that article. With an odd number, the start and finish are always made at the exact center and a "balanced condition" results such as we do not have when using the joint recommended by Mr. Jackson.

Newark, N. J. W. F. SCHAPHORST.

Guide Aids in Undercutting Commutator Mica

DIFFICULTY will be experienced in keeping the cutting tool on the mica when undercutting a commutator with either a thin hacksaw or other cutting tool. The tool is likely to slip and scratch the segments.

In the sketch is shown a useful guide for the cutting tool, which can be easily made. A is a piece of dry,



ADJUSTABLE GUIDE PREVENTS SLIPPING OF CUTTING TOOL WHEN UNDERCUTTING MICA ON A COMMUTATOR

hard wood. B is a piece of flat spring steel to which A is fastened. C is a piece of old soft leather belt, placed between the spring and the face of the commutator.

When cutting the mica, the side D is used as a guide for the cutting tool. E is the commutator. B must be made of a length more than half that of the circumference of the commutator in order that it will hold in place at any point.

Toronto, Canada. JAMES E. NOBLE.

Pumping Hot Water Requires Special Attention

SUPPLYING boilers with hot feedwater results in considerable economy but pumping difficulty increases as the temperature rises. With cold water, pumps can lift water by suction to a certain height which is affected by the water temperature and atmospheric pressure. When the water temperature rises above 160 deg. F., it is impossible to lift water by suction, hence it is necessary to flood the pump by causing the water to flow into the pump by gravity.

At temperatures above 165 deg., it is necessary to supply the water to the pump under a positive head ranging from about 3 ft. for 170 deg. water to about 12 ft. for 210 deg. water. As the altitude rises above sea level, the head must be increased until at 2000 ft. the head required exceeds that at sea level by about 50 per cent. This positive head is necessary because, as the hot water passes through the pump, a vapor pressure is set up in the suction pipe, which renders lifting by suction impossible, as it destroys the vacuum. As the

pressure is reduced or as the water temperature rises, vapor is given off more rapidly.

By supplying the water under sufficient pressure, vapor will not be formed as vacuum spaces, in which vapor can collect, are eliminated. The entire layout of the piping should be as short as possible and the diameter of the piping a little more liberal than when pumping cold water. All turns should be gradual and constricted passages should be avoided, otherwise eddies will be formed as the water flows through them and vapors may form a vapor lock.

When using reciprocating pumps, the bucket speed must be much lower with hot than with cold water. Makers of pumps indicate the correct speeds to use with hot water, as well as with cold water and these speeds should not be exceeded. With centrifugal pumps, the speed must be lower for hot than for cold water. Gland packing frequently may be a source of trouble with these pumps. Metallic packing is not affected as much as soft packing by hot water and it usually gives better results.

Brentford, England. W. E. WARNER.

Chimneys Need No Painting

NOT LONG AGO, I saw a beautiful white chimney. It was a new chimney built of reënforced concrete and the cost of painting, I was informed, was close to $100.

Within a month after it had been painted, some ugly black, crooked streaks appeared all around, beginning at the top and terminating about halfway down. Whether these streaks were caused by steam from the soot blowers, from exhaust, from blowoff or from soot accumulating at the top and then washed down by rain, I do not know. Anyway, the streaks are there and the chimney no longer looks like a work of art. Its beauty was of short duration.

My contention is that it is a waste of money to paint a large concrete chimney. Concrete doesn't need paint and besides, paint doesn't improve the appearance of concrete. Who has ever seen a concrete dam, pavement, retaining wall, sidewalk or breakwater that has been painted? Neither does a brick or tile chimney need paint. Steel chimneys should be painted to retard corrosion. Concrete, brick and tile do not corrode. Why paint them?

Often, it is good advertising to paint the firm name on a concrete, tile or brick chimney, but, as a preservative, paint is not necessary and as a beautifier, it seldom beautifies.

Newark, N. J. N. G. NEAR.

Suction Pipe on Pumps Should Not Be Reduced

DURING my experience as an engineer, I have been called upon to make steam pump repairs in many sections of Canada. One thing which is frequently done, even by experienced men, is to reduce the size of the suction pipe at least one or even two sizes smaller than the opening in the pump.

When the lift is only a few feet, the horizontal run of the suction pipe short and the speed of the pump slow, the pump will give no trouble but if you increase the pump speed or lengthen the height or length of the pipe, trouble starts at once. I believe that about 10 per cent of the boiler feed pumps I have been sent to overhaul have had suction pipes smaller than the suction pipe opening in the pump. There never will be trouble due to increasing the size over what is called for but the size should never be reduced. Reducing the size of the discharge is wrong but not nearly so likely to cause trouble as reducing the size of the suction.

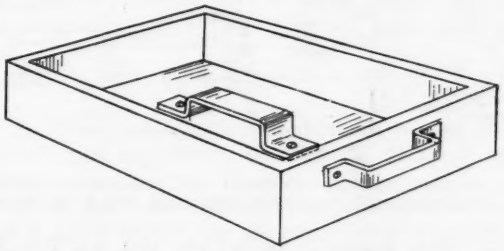
Reduction in the price of the pipe, fittings and valve is the only possible reason for using a smaller pipe. In my opinion, it is false economy to use the smaller pipe, even when conditions at the time of installation are such that it is all together probable the pump will give satisfactory service.

Small suction or discharge pipe results in greater friction which means increased cost. The loss may be small but many power plants have had to go out of business because of small losses.

West Vancouver, B. C. JOHN ELLETHORN.

Handy Carrying Device

DRAWERS FILLED with tools, packing or supply parts may be conveniently carried by means of a small handle of the drawer-pull type, fastened in the bottom of the drawer as shown in the sketch.



DRAWER-PULL HANDLE FASTENED TO BOTTOM OF DRAWER MAKES CONVENIENT CARRYING DEVICE

In cases where the drawer is partitioned into sections, the handle is fastened in the central section. The handle does not interfere with closing or removing drawer if it is made sufficiently low.

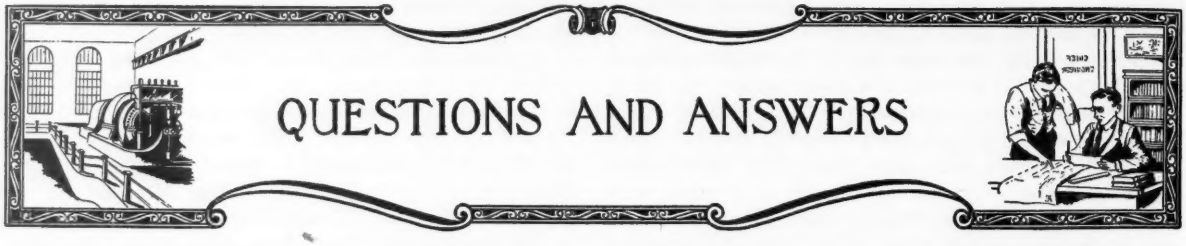
Washington, D. C. G. A. LUERS.

Coal Weight Checked

FOR SEMI-AUTOMATIC weighing of coal, an ingenious arrangement was recently developed by a prominent mechanical engineer. A wheelbarrow is placed on platform scales and is loaded by hand by means of scoop shovels. As soon as the load of coal is "standard" in weight, two lights, easily seen by the shoveler, are lighted simultaneously. Each load, therefore, contains a definitely known amount of coal. At the same time, a recording instrument located in the engine room registers each standard load.

Knowing the exact amount of fuel being burned under all conditions of load is an obvious advantage. It is an excellent way in which to keep a continual check on efficiency and economy.

Newark, N. J. W. F. SCHAPHORST.



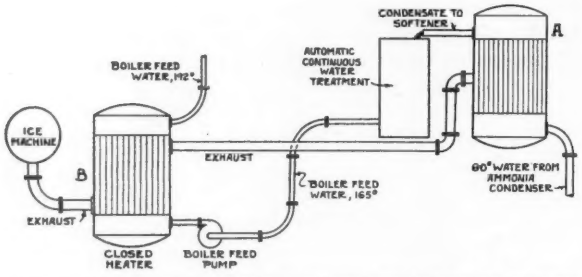
QUESTIONS AND ANSWERS

Back Pressure Increases Feed Temperature

YOUR OPINION on the following problem of boiler feedwater temperatures is desired.

We manufacture ice by the distilled water system. Our plant consists of four 150-hp. return tubular boilers of which one is used as a standby. Our boiler pressure is 125 lb. Besides making 140 t. of ice daily, we supply cold storage, using approximately 6 t. of ice daily for this purpose.

Of five steam condensers of precisely the same capacity and design, we use one, which is shown at A in the sketch, as an open heater for boiler feedwater



FEEDWATER PASSES THROUGH TWO HEATERS IN SERIES BUT ATTAINS A TEMPERATURE OF ONLY 194 DEG.

alone. This heater is 36 in. dia. and has 120, 2-in. tubes, 6½ ft. long. An automatic regulating valve controls the quantity of water through the open heater according to the demand of the boilers.

Well water, after being pumped through the ammonia condenser, enters heater A at 60 deg., then passes through a water softener from which it emerges at 165 deg. It then flows by gravity to the boiler feed pump and, at boiler pressure, is forced through closed heater B into the boilers.

Closed heater B, though of the same design as open heater A, has a slightly larger capacity and receives the steam from the ice machine direct. It has 121, 2-in. tubes 7 ft. long.

My contention is that the closed heater B, receiving the water at 165 deg., should raise its temperature to the boiling point instead of to only 192 deg. There is no back pressure on the exhaust line.

Can it be that a leaky valve on the water softener is mixing cold water with water from the open heater A? E. N. W.

A. It would be a simple matter to check any leakage in the water softener but this is not the cause of inability to raise the feedwater temperature to 212 deg.

You designate heater A as an "open heater" but indicate that it contains tubes, from which we infer that the steam and water do not mix together. In this case, such a heater is technically not an open heater but a closed heater.

Where closed heaters are employed, such as shown at B in the sketch, there must be a marked difference between the two temperatures of water and steam and as you say that there is no back pressure, the temperature of the steam will be practically that at atmospheric pressure, which would be 212 deg. The rise in temperature from 165 to 192 deg. is, therefore, as much as could be expected, since the heat must be conducted through the material of the tubes.

You could install an oil separator and open heater, in which the steam and water mix in place of heater B. Such an installation would cost about $500. The question is whether such an expenditure would be warranted; we doubt it. It is generally considered that, roughly, a gain of 11 deg. rise in feedwater temperature represents a saving of one per cent of coal, if exhaust steam, otherwise wasted, were used. By referring to your coal cost, the advisability or inadvisability of making the suggested changes in your installation will be apparent to you.

Boiler, Engine and Compressor Efficiencies

PLEASE EXPLAIN the following problems:

1. What is the efficiency of a water tube boiler operating under 125 lb. press., burning 1333 lb. of coal per hour and evaporating 11,333 lb. of water per hr.? The feedwater temperature is 204 deg. F., the coal has a heating value of 14,000 B.t.u. per lb., and the stack temperature is 800 deg.

2. What is the efficiency of a 15 by 14-in. engine running 250 r.p.m. on 125-lb. steam pressure at the boiler and driving a generator delivering 920 kw.?

3. What is the efficiency of a two-stage, steam-driven air compressor which compresses air to 85 lb. and uses steam at 125 lb. pressure, the dimensions of the cylinders being as follows:

Steam cylinder, 8 by 12 in.
Air cylinder, 12 by 12 in.
Steam cylinder, 8 by 12 in.
Air cylinder, 7½ by 12 in.

4. If the vacuum was 26 in., how many pounds of steam would be saved an hour?

5. How do you find the temperature at which water boils under 15 and 300 lb. pressures? M. S. C.

A. 1. The general formula for efficiency in any system or operation is: output ÷ input = efficiency. Care must be taken to express all factors of the equation in the same units.

In your first question, where a boiler evaporates 11,333 lb. of water at 125 lb. press. when burning 1333 lb. of 14,000 B.t.u. coal an hour, we first find the heat

content of 125-lb. gage steam from steam tables. This is 1192 B.t.u. per lb., measured above 32 deg. F. As your feedwater temperature is 204 deg., the heat in the feedwater is 204 — 32 = 172 B.t.u. per lb., leaving 1020 B.t.u. per lb. of steam to be supplied by the boiler. The efficiency, therefore, is

$$1333 \times 14{,}000 \div 11{,}333 \times 1020 = 62 \text{ per cent}$$

The stack or furnace temperatures have no bearing on this particular problem.

2. On the remaining questions, there is not enough data to answer them comprehensively, but we will assume that all water evaporated from the boiler in the first problem is to be used in the engine or air compressor mentioned in the second and third questions. In this case the engine uses 11,333 lb. of steam in generating 920 kw. This is equivalent to 123 lb. of steam per kw-hr. As each pound of steam has a heat content of 1192 B.t.u. and a kilowatt-hour corresponds to 3412 B.t.u., the thermal efficiency of the engine and generator may be computed, as before, by dividing the output by the input.

$$\text{This is } 3412 \div 123 \times 1192 = 2.33 \text{ per cent.}$$

Knowing the efficiency of the generator, which may be obtained from the makers, the overall efficiency of the unit—2.33 per cent—may be correspondingly reduced.

3. The overall efficiency of an air compressor is the product of its mechanical and compression efficiencies or it is the adiabatic horsepower divided by the brake horsepower. The adiabatic horsepower of 1 cu. ft. air at sea level compressed to 85 lb. g. in two stages is about 0.162 hp. By assuming a certain speed for your compressor and assuming a volumetric efficiency, the displacement of the low-pressure cylinder in cubic feet per minute may be computed and from this the adiabatic horsepower calculated. Then, as one horsepower corresponds to 2512 B.t.u., the thermal efficiency of the compressor can be found in the same manner given in the case of the steam engine.

4. Assuming that you mean the increase in available heat of 125 lb. steam expanded to 26 in. of vacuum over the same steam expanded to atmospheric pressure, we find that 125 lb. g. steam has 1192 B.t.u. If this is expanded adiabatically to 15 lb. press., the heat content would be 1030 B.t.u., which is a drop of 162 B.t.u. If it is expanded to 26 in. vacuum, which is about 2 lb. absolute, the heat content would be 914 B.t.u. per lb., which is a drop of 278 B.t.u. If the Rankine cycle efficiency ratio of the engines were 70 per cent, it would utilize 113 B.t.u. per lb. in the first case and 195 B.t.u. in the second which, not considering other factors, would make the steam consumption 113 ÷ 195 = 58 per cent of the non-condensing value.

5. The only way to find the steam temperature corresponding to a certain pressure is to use steam tables. A few of the more important and more frequently used values may be memorized as, for example, most engineers know that water boils at 212 deg. at sea level or atmospheric pressure and at about 315 deg. at 100 lb. g. pressure.

Corliss Valve Leakage Detected Through Indicator Cocks

REFERRING to the question asked on page 794 of the July 15 issue, leakage through a Corliss valve may be detected by opening the indicator cocks on one side and turning the steam into the steam chest. Any leakage of steam through the closed steam valves will appear at the indicator pipe openings.

If your steam valves have lap when the wristplate is central, place the wristplate in central position. In case of a double eccentric engine, the steam valves will have lead with the wristplate central, therefore one end of the cylinder only can be tested at a time. If there are no indicator pipe holes at the side, the exhaust valve can be removed and any leakage of steam will appear there. E. G. H.

High Pressure When Starting Up Carbon Dioxide Machine

I OPERATE A 12-t. carbon dioxide refrigerating machine, with which I am experiencing some difficulty in the matter of starting up. When the machine is started, the pressures go too high and in order to bring the high pressure down to 63 atmospheres, I must open the expansion valve fairly wide, which brings my low pressure up to 40 atmospheres. Then I slowly close my expansion valve until it is expanding my gas. This is for direct expansion; for ice water and for storage, I can lower my temperature in the fur vault about 3 or 4 deg. an hour.

Kindly advise what I may do to remedy this trouble.
R. E. G.

A. The trouble experienced when starting the machine is not an unusual one when a system is heavily charged.

After the machine has been shut down for some time and is again started, the amount of heat in the gas that will return from the evaporating coils is great for a short time.

Before shutting down the machine, the system is pumped down and the receiver and condenser are just about filled to capacity with liquid. Then, when starting up, the condenser has not enough effective surface to remove the heat at the rate it comes from the evaporating coils.

Relieving some of the liquid through the expansion valve is the only way to handle this condition.

Of course, it would be a better plan to withdraw a sufficient amount out of the system so that the condenser would not be loaded so heavily.

There is another cause for high condenser pressure when starting up. If the expansion valves or main liquid valve leak, some liquid will pass into the evaporating coils while the machine is shut down. This liquid will become superheated gas and when the machine is started, the condenser will be overloaded till the hot gas is pumped back and condensed. Test the main liquid valve and the expansion valves.

A condensing pressure of 63 atmospheres is not excessive unless the temperature of the condensing water is below 75 deg. F.

See that the inner water pipes of the condenser are clean.

Goldsboro, N. C. A. G. SOLOMON.

EDITORIAL COMMENT

Power By and For the People

While management of any industry must remain the responsibility of comparatively few, whether that industry be government or privately owned, the ownership may be and often is widely distributed. Large stockholders have a greater stake than those with small holdings and take, naturally, greater interest in their property but all receive returns in proportion to their investments.

In the power industry, an investment of 22 billions of dollars has been made by five million owners, ranging from banks and insurance companies to individual employes and customers. Those who manage the industry can hold their jobs, so long as they give service for the people which is satisfactory and produce returns on investment by the people which are satisfactory.

To secure best economic results, supply must be from a single source, or coördinated sources, over a single distribution system. This is true, whether it be a central station system, a group system serving a number of plants or an individual industrial plant. This, in the case of a public utility, means a natural monopoly, if lowest cost of service is to be attained.

Restriction and regulation of rates, of issue of securities and of returns to investors naturally follow, in order to safeguard the interests of those who buy service and those who invest in securities. Such safeguard, controlled by the people, now exists in 46 states. Large customers and large owners have the greater interest in proper regulation but regulating bodies, responsible to the people, have the duty to see that justice is accorded to everybody.

Service, 100 per cent effective is not always secured by the people from their hired employes. Results of elections seem, sometimes, to indicate that the majority does not want such service but that, humanity being human, special advantages and privileges are desired. From officials chosen on such a basis, favoritism and playing of politics for individual advantage are to be expected. The employe does what he has been hired to do but doesn't always favor those who think they ought to have favors.

What has government ownership to offer? Management must still be in the hands of a few, who will have large authority. Large property owners, users of power and taxpayers will have the larger interest in securing favors, if any, and, if officials or managers are elected or chosen on the special privilege basis, the large user or owner has more effective means for securing favors than does the smaller customer. Corrupt action will result in benefit to the few rather than to the people.

If administration is uneconomical, which has been the case in many government owned and operated utilities in all countries, the loss falls on the people, with resulting higher cost in rates paid or in taxes. There is no obligation on management to give satisfactory return on investment, for the people are "holding the bag."

Government operation can be successful, as has been proved in many cases. Also it has great possibilities of poor success or failures, as has been proved in many cases, and in practically every case where political advantage has been a factor.

Power development by utilities whose ownership is widely distributed with service and costs supervised by representatives of the people is power by and for the people and can be kept free from political favoritism and manipulation if the people so will.

Coal Supply

For some time, supply has met or exceeded demand, so that a quiet market has resulted and prices have been low. The growth of production from non-union mines to 80 per cent of the total has changed the situation in a few years and abandonment of the Jacksonville scale agreement, while likely to affect this ratio of production, is not likely to reverse it or to have much effect on supply and prices. Illinois and Indiana mines will be placed on a better competitive basis but conditions in the West Virginia, Pittsburgh and Ohio fields will remain about as heretofore.

As an immediate result, demand has collapsed, purchasers awaiting developments. Probably, hand-to-mouth buying will be in order for some time, as there is a possibility of even lower prices. In any event, the new situation seems to ensure adequate coal supply for the winter at prices no higher than have prevailed, so that the only stocking up necessary is to provide against transportation delays during the winter season. The situation enables the power-plant buyer to be discriminating in his purchasing and to secure the coal best suited to his needs.

Unemployment

During the past few months, various professional attention-callers and viewers-with-alarm have been diligently practicing their professions with respect to what they termed an unemployment crisis in the United States. Many times, when engaged in their jobs of viewing this unemployment condition with alarm, they have given the impression that they were basing their alarm on a great deal of information that was not generally available to the public.

Applesauce! say we. We have a suspicion that maybe there hasn't been any unemployment crisis at all. First of all, just what is meant by unemployment? Is a man unemployed when he refuses to accept a job not to his liking, or is it when he cannot find work at all? Or is it when he cannot find a job in which he can use

his previous training? How many people in this country usually work and at what do they work? How many work only when they can find no other means of support? Does anybody owe a man a living? If so, who and what for?

To whom should we look for answers to such questions as these? The church? The Department of Labor? Trade associations of manufacturers?

Just what is the effect of the increased use of automatic machinery in industry and on the farm upon the number of men employed in industry and the type of jobs involved? Certain industries (not always making luxuries, either) last year reported a period of "profitless prosperity." That is, the profit on a larger volume of sales was eaten up by the increased cost of overcoming sales resistance to make those sales. Was this sales resistance caused by unemployment and lack of purchasing power? Or was there a closer approach to the saturation point in those lines? How much of this unemployment talk is connected with the spectre of presidential election hard times.

We realize, of course, that a professional viewer-with-alarm will not be embarrassed in the slightest by these questions. Yet until they are answered and a hundred others like them, no one will ever know whether there was unemployment in the United States this year or not. Possibly there was; then again maybe there was not. Nothing is more dangerous to a nation than the circulation of an idea of this kind without any facts on which to base it. Where are the facts of which this persistent bogey-man of unemployment was built?

Off Duty

Old Mother Nature—we use the expression from force of habit for she can't be very old, judging from the way she keeps scientists on the jump—must be having the time of her life these days. Always an elusive girl, she is doubly so today. More charming than ever, mysterious beyond expression, the darling of all scientists, no sooner have they cornered her in the hope of eliciting some of her many favors, than she executes an unlooked for movement and is off, leaving the scientist more bewildered than before.

Thirty years ago, all was fine. We knew what matter was, and we knew what light was. Matter was composed of atoms, than which there could be nothing smaller, and light was a wave motion in the ether. What could be sweeter?

Today all this secure knowledge has been shattered. The atoms which we once thought indivisible particles have been shown to be complex systems composed of very much smaller electrons. Light, thirty years ago so generally known to be waves, today seems again to be of a corpuscular nature, as Newton thought it to be. Concepts of everything have been turned topsy turvy. Even the formerly unchallenged law of the indestructibility of matter today is only partly true. Now, the very electron, so enormously important in the make-up of things is undergoing the "third degree" and if recent experiments are sound, the electron does not seem to be a particle of anything.

The Universe which we once thought so real seems to be no more than "such stuff as dreams are made of." As Bertrand Russell aptly expressed it recently, "The world is not composed of things."

This idea is not new to metaphysicians, but in the past the metaphysician could not point to the technique of science as being on his side. Today, the findings of the physicist point more and more to the fact that the electron, that primordial element of which everything else is made, is merely a manifestation of energy—no more permanent, no more absolute than a vision in a dream.

Coming from interstellar space, Millikan finds the cosmic ray—inconceivably elusive, yet more powerful, more penetrating than the hardest radium rays. Passing through 18 ft. of solid lead where our most penetrating x-rays are stopped by one-half inch of lead, these rays are indicative of enormous energy transformations. They signal the continuous rebirth of the Universe.

Out in space, beyond the limits of our own galaxy, the primordial elements, the proton, the electron, the hydrogen atom, are building up to form the heavier elements, helium, silicon, iron. Here lies the secret of the cosmic rays. When hydrogen atoms combine to form the heavier elements, eight one thousandths of their mass disappears to form an equivalent amount of energy. This energy is the cosmic ray. Every time a hydrogen atom combines with other hydrogen atoms, eight one thousandths of its mass thus changes into radiant energy. Though this is happening hundreds of thousands of billions of miles or light years away, the rays tell the story.

This is not guesswork nor idle philosophic speculation but the result of accurate physical measurement and calculation. Thanks to Einstein, whose theory predicted this, Millikan was able to solve the problem not qualitatively but quantitatively. Speaking of Einstein, let it be said here that so far not a single one of all the predictions made by the Einstein special theory of relativity have been found incorrect.

What becomes of the energy in the cosmic ray? Is it destined forever, and ever to wander, homeless through space like the Wandering Jew? Will our entire universe, some day, all have turned into radiant energy and will there be nothing but light?

Well, why not? If the universe is infinite in extent, as is commonly believed, what else can we believe? Certainly, the thought of the universe evaporating into light is no more disturbing than the thought of an infinite universe itself.

But perhaps, and the Einstein theory implies it, the universe is not infinite in extent. Space may be curved, says Einstein, and if this is so, cosmic rays starting from any point in the universe would eventually converge to the opposite "pole" of the universe where they might again be transformed into matter.

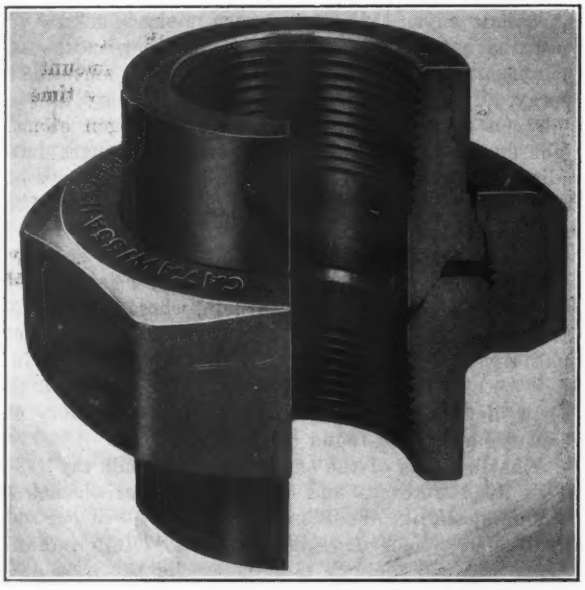
What a thought! A finite universe. Matter evaporating into radiant energy at one pole, traveling around the universe and distilling at the opposite pole!

All this sounds strange and confusing and perhaps it is; yet we seem to be coming to something. The more we pursue our studies of nature's mechanism, the more are we impressed with the significance of energy. More and more, as we advance in our knowledge of modern physics, does it become evident that the secret of the universe is contained in the ultimate explanation of the term energy. Who knows, but that tomorrow someone will discover it. Then truly all will be light.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Unions Hot Forged from Steel Bars

FOR ALL ORDINARY PURPOSES for which joint unions are used, for use with hydraulic pressures up to 2000 lb. per sq. in. and for saturated steam pressure up to 500 lb. per sq. in., Catawissa standard unions



SECTION OF EXTRA-HEAVY CATAWISSA FORGED UNION

have recently been placed on the market. For high-pressure and temperature work, extra heavy units are made, designed for hydraulic pressures up to 6000 lb. and, when fitted with monel metal seats, for highest pressures and temperatures at which steam is used. These are shown in the accompanying illustration.

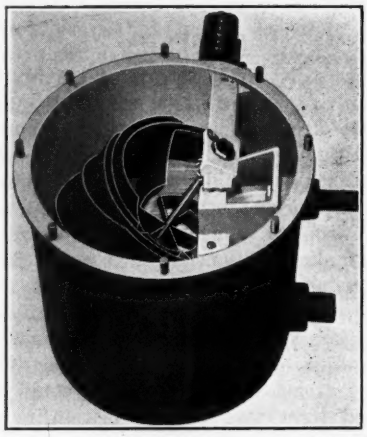
These unions are made from hot forged steel with the seats carefully ground and are designed to require no packing. They are made of hot forged steel from solid steel bars. The seat has a 55-deg. angle on the female end to a ball on the male end.

For ammonia, hot gases, high pressures or superheated steam, unions with steel to steel seats are recommended. For water, air or gas lines and most ordinary purposes, they are furnished with brass to steel seats when specified, while for use with alkalis, acids and to withstand the corrosive action of high temperature steam and gas, forged monel metal seat rings are supplied. The unions are made in sizes from ⅛ in. to 2½ in. by the Central Forging Co., Catawissa, Pa.

Republic Condensation Meter

EMBODYING SEVERAL interesting features, the rotor type condensation meter shown herewith has recently been placed on the market. The meter consists essentially of four parts: cast-iron housing, rotor, bracket assembly and counter. It is designed so that, by removing two screws, the bracket assembly can be removed and the rotor lifted out for cleaning and servicing of the meter, without disturbing piping connections.

Condensate to be measured enters the diffuser or box-shaped casting, flowing down into the rotor through a large opening, while any steam present passes out through the opening in the top of the diffuser, thus preventing the rotor from spinning due to the action of the steam. The rotor is of sheet copper, with its compartments arranged to measure the condensate accurately. Rotation of the rotor shaft is transmitted



CONDENSATION IS MEASURED BY COMPARTMENTS IN ROTOR AND IS RECORDED BY CYCLOMETER GEAR TRAIN

through sprockets to a cyclometer gear train in a housing on the side of the meter. This gear train reads direct in pounds and fractions up to 9,999,999 lb.

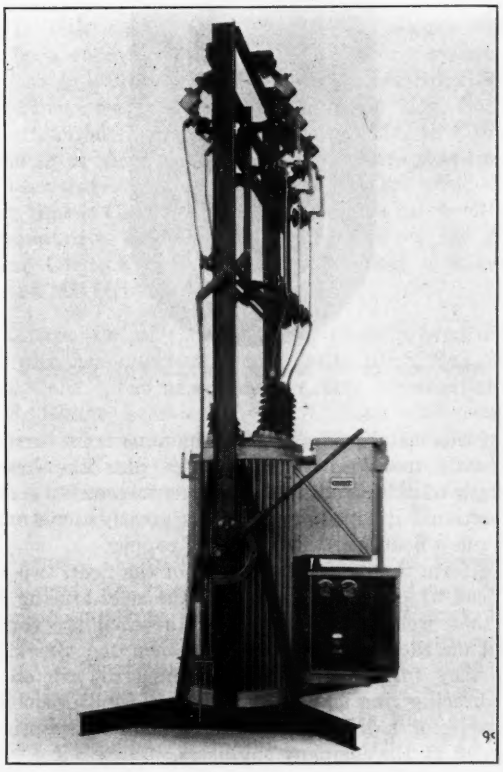
Construction throughout is stainless steel except for the copper rotor and the specially designed upper bearing. This is an inverted cone bearing, designed to be self-cleaning, with monel metal ball bearings and bronze race. Bottom bearing is an inverted stainless steel pivot bearing. Bearings are designed to be self-cleaning and to require no lubrication. The entire meter can be sealed with a single lock.

It is made by Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., in three sizes to cover all ranges of operation, viz: 0—1200 lb. per hr., 0—3600 lb. per hr., 0—7200 lb. per hr.

Unit Substation Reduces Costs

COMBINING IN ONE unit, a power transformer, switching facilities, overload and short circuit protection, together with a means of metering, a new design of substation developed by the Condit Electrical Manufacturing Corporation, of Boston, Mass., seems to offer a new way to reduce the cost of power distribution systems, at the same time affording reliability of operation and safety.

This apparatus utilizes a standard 3-phase star connected primary power transformer of the usual design except arranged for inserting an oil circuit breaker in



UNIT SUBSTATION DEVELOPED BY CONDIT ELECTRICAL MFG. CORP.

the connections between the primary winding and the common or star connection point. This oil circuit breaker, because of the transformer reactance, need have a very small proportion of the interrupting capacity of an oil circuit breaker on the line side of the transformer. Closing the oil circuit breaker energizes the transformer. Opening the oil circuit breaker deënergizes both primary and secondary windings. Series wound type current transformers suitable for metering and potential transformers are placed within the power transformer compartments.

A set of primary and, if desired, secondary disconnects are mounted above the transformer on a simple channel iron structure integral with it. The disconnects are interlocked to prevent opening except when the oil circuit breaker is open, thereby insuring that neither load current nor magnetizing current can be interrupted on the disconnecting switches.

Protection for the primary leads and windings is afforded by a fuse rated for short circuit only. Overload protection is secured from secondary current transformers energizing trip coils of the oil circuit breaker, causing it to open and deënergize both primary and secondary windings.

The whole structure makes a compact, complete unit substation, resulting in great economy of equipment and installation cost combined with ease of operation and maintenance.

Air Filters for Pipe Lines and for Building Use

BY DELIVERING clean, dry air to air-using machinery and tools, it is recognized that many troubles in them caused primarily by dirt can be prevented. For this purpose, a new filter intended to be

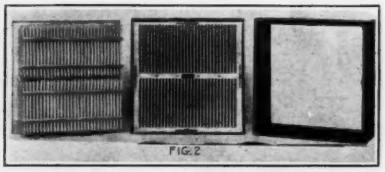


FIG. 1. FILTER MEDIUM OF FELT, MADE INTO POCKETS, FITS IN HOUSING SCREWED INTO PIPE LINE

FIG. 2. FOR BUILDING USE, PANEL FILTER ELEMENTS CARRY TWO ROWS OF WIRE CLOTH POCKETS COVERED WITH FILTERING MATERIAL

easily inserted in the air lines has recently been placed upon the market.

This filter consists of an aluminum housing enclosed in a pressed steel housing designed for a working pressure of 125 lb. The filter, mounted inside the aluminum housing consists of a felt filter medium formed in pockets over radial wire screen fins grouped around a central outlet. The large capacity inserts are designed to pass 250 cu. ft. of free air per minute and contain 20 sq. ft. of felt within a volume slightly smaller than a cubic foot.

Air enters the top of the filters and is thrown against the inner wall of the steel housing by a shield over the top of filter. The downward velocity carries water, oil, and most of the grit to the bottom of the shell. All remaining water, oil, dust and grit is said to be caught by the filter. A drain cock at the bottom removes water, oil and sediment.

By closing a valve to shut off air going into the filter housing and opening the drain cock, the air in the outlet pipes or hose is blown back through the filter proper, removing all material on the filter surface. The manufacturer claims that in this way the filter can be cleaned in about 10 min. while in operation and that cleaning is necessary but twice a year under ordinary conditions. No oil drain or cleaning tanks are necessary and the filter does not have to be removed when once in operation.

This unit, Fig. 1, known as the Model C P pipe line filter, is made by the Staynew Filter Corp., Rochester,

N. Y. The company has also brought out a panel filter unit, Fig. 2, which is being used in filtering large volumes of air for building ventilation.

Each panel consists of two pressed-steel or aluminum frames which support a series of hollow fins or pockets formed of wire cloth and arranged in two rows. Each row of fins is covered with a single piece of an extremely fine textured filter material.

This filter, it is claimed, can be operated under ordinary conditions for several months before cleaning is necessary. The filter can be cleaned by a special air suction cleaner by placing a special nozzle over the face of the panel where the openings into the sockets are located. Cleaning is done without removing the panels of the filter from the supporting frames.

Mica Undercutter for Commutators

FOR UNDERCUTTING motor commutators without removing the armature or the brushes, the Ideal mica undercutter has recently been placed on the market. As shown, the device consists of a ¼-hp.,

UNDERCUTTER IS DESIGNED FOR OPERATION WITHOUT REMOVING BRUSHES

110-v. or 220-v., 60-cycle, 1725-r.p.m. motor, shaft, sheath, undercutter head and circular saws ⅞ in. in diameter or milling cutters of the same diameter.

This undercutter, made by Ideal Commutator Dresser Co., Sycamore, Ill., is designed to be used on Commutators of all sizes. It is designed to slot approximately ¼ in. from the risers. It has a depth gage next to the cutter so that the depth of the cut can be measured. It also has an adjustable micrometer guide, made so that only one slot need be cut by hand, the guide operating in the next slot. The plate over the gears is attached tightly to prevent grease from escaping and to keep mica from entering the gears. The manufacturer recommends ⅞-in. milling cutters or saws and the milling cutters supplied with the machine have a 50-deg. angle to cut a V slot.

Reliance Monel Metal Float for High Pressures

TO MEET the modern and logical tendency to higher pressure boiler operation in power plants, the engineers of the Reliance Gauge Column Co., Cleveland, Ohio, have developed a new float of monel metal. The

NEW FLOAT OF MONEL METAL FOR SAFETY WATER COLUMNS

use of this metal makes the float immune from corrosion and scale troubles. These factors plus the bracing strength of the structural steel reënforcement, seen in the sectional illustration, increases greatly the strength of the new float over those made of copper.

To form the monel metal shell of the float, two cups are used which are pressed on to the steel bracing ring and then welded. The edges of the shell are slightly belled on the inner side so that when the two halves meet they form a groove, into which the rib on the shell bracing ring snugs, assuring it a rigid immobility. The welding is done on machines which were especially designed by the company engineers.

Power Pipe Cutter

TO CUT OFF pipe and tubes from ¼ to 2 in. in diameter, a portable production machine has recently been placed on the market by The Oster Manufacturing Co., Cleveland, Ohio. The cutter disc, contained in a movable arm, is brought down on the pipe which rests on rollers. This is to permit the pipe to remain at right angles to the cutter disc at all times, to insure a clean, square cut and to lengthen the life of the cutter disc.

Action of the arm holding the cutter disc is controlled by a screw feed and hand wheel, giving compound leverage on the disc. The extra leverage obtainable together with rigid support on both sides of the cutter disc and abundant power of the machine is intended to enable the operator to hurry the cut as much as desired, thereby increasing the production. The machine is equipped with a length gage which can be set to cut any length nipple from "close" to 3 ft. on either side of the cutter disc. If a quantity of pipe is to be cut

to lengths longer than 3 ft., an ordinary piece of pipe can be used with the standard stock stop as a length gage. The new cutter can be furnished in either belt or motor-driven models, a standard one-horsepower motor being supplied with the motor-driven type. An all metal stand for mounting the machines, which places them at exactly the right height for convenient operation, can be furnished as extra equipment.

News Notes

RILEY STOKER CORP., Worchester, Mass., announces the appointment of L. E. Griffith to succeed the late William Pestell as sales manager of Riley Stoker Corp. Mr. Griffith a graduate of Lafayette College in 1912, has been connected with Thompson-Starrett Co., The Babcock & Wilcox Co. and others. When Riley Stoker Corp. purchased the United Machine & Mfg. Co. who manufactured the Harrington Stoker, Mr. Griffith was president of the latter organization. Since that time he has been district manager of the New York office of the Riley Stoker Corp. W. L. Schultz, who has been sales representative of the New York office of the Riley Stoker Corp., has been appointed district manager to succeed Mr. Griffith.

ELLIOTT CO. of California has recently been organized with headquarters at 813 Rialto Bldg., San Francisco, Calif. The officers of the new organization are W. S. Elliott, president; F. A. Calmus, vice-president and general manager and C. W. Moore, secretary and treasurer. H. A. Otterson has been appointed manager of the electric power department of the Ridgway works of the company.

NATIONAL FLUE CLEANER CO., INC., of Groveville, New Jersey, has recently appointed several new Southern representatives, as follows: Fuel Efficiency Engineering Co., American Trust Building, Birmingham, Ala.; A. S. Furtwangler, 4 South Broad St., Charleston, South Carolina; Reed & Duecker, Inc., 171 North Main St., Memphis, Tenn.; Buckmaster-Luck-Malochee, Inc., Industrial Homestead Building, New Orleans, La., and Henry Eggelhof, Construction Industries Building, Dallas, Texas.

WAGNER ELECTRIC CORP., 6400 Plymouth Ave., St. Louis, Mo., announces that Fred Johnson, formerly of the St. Louis sales office, is now manager of the Los Angeles branch office. The corporation also announces that Alex L. Miltenberger, formerly Pacific Coast manager, has been transferred to St. Louis as branch manager.

AT A RECENT meeting of the directors of Allen & Billmyre Co., Inc., Grand Central Palace, N. Y., J. F. Billmyre, one of the founders of the company was elected president. Hugh V. Conrad, formerly with Ingersoll-Rand Co. was elected vice-president and secretary; Owen S. Lieberg, vice-president in charge of sales; F. A. Dawes, treasurer and W. A. York assistant secretary and assistant treasurer.

FOSTER WHEELER CORPORATION, 165 Broadway, New York, has opened a direct branch office at 109 Tchoupitoulas St., New Orleans, La., in charge of Harry W. Parsons.

DAY & ZIMMERMANN Engineering & Construction Co. announces the removal of its Philadelphia office to 112 North Broad St., Philadelphia, Pa.

SARCO CO., Inc., 183 Madison Ave., New York, has recently announced two new steam traps. One of these is the type S-75 trap for process steam of pressures up to 75 lb. with heavy wall helical bellows with renewable monel metal valve head and seat, both easily renewable. The other trap is a new combination float and thermostatic unit for steam pressures up to 10 lb. per sq. in., recommended for heavy duty work. Trap is designed to relieve itself of air by thermostatic bypass incorporated in the trap body. A float mechanism actuates the main valve. The trap is supplied in capacities ranging from 550 lb. at ½ lb. differential pressure to 2000 lb. of air per hour at 10 lb. differential pressure.

J. W. CLIFF has recently joined the MacGregor Valve Co., 3560 Chouteau Ave., St. Louis, Mo., as production manager. Mr. Cliff has held executive and engineering positions with such firms as the Power Accounting Co., Hyatt Roller Bearing Co., Wright-Martin Aircraft Co., Lehigh Accounting Co., Weston Instrument Co., and for the last 5 yr. has been shop superintendent manufacturing Merco-Nordstrom valves.

IRA J. OWENS ORGANIZATION, 400 First National Bank Bldg., Chicago, announces that it is prepared to enter the field of engineering and diagnosis of industrial conditions and analysis of organization management, material handling and other costs.

CONDENSER CLEANERS MFG. CO., 422 First Avenue, Pittsburgh, Pa., is placing on the market its most recently designed condenser tube cleaner, known as the Conco 4.

ACCORDING to a recent news announcement, Stone & Webster Engineering Corp. has been formed with a capitalization of $9,500,000 and has taken over from Stone & Webster, Inc. its construction and engineering business. It has also acquired from the North American Co. the engineering and construction company known as McClellan & Junkersfeld, Inc.

OTTOMAR H. HENSCHEL, who has maintained a consulting office at 50 Keefe Ave., Milwaukee, Wis., has now opened another office in Room 401 Commerce Bldg., 4th and Wells Sts., Milwaukee, Wis.

DEMAND FOR a powerful drill of ¾ in. capacity to take straight shank drill bits has led The Black & Decker Mfg. Co., Towson, Md., to put on the market a ¾-in. heavy duty portable electric drill. This drill is equipped with a powerful universal motor, operating on direct or alternating current and the armature and spindle thrust are mounted on ball bearings. The 3-jaw geared chuck uses straight shank bits.

PAUL R. DUFFEY, electrical and power engineer with the Celanese Corp. of America, Cumberland, Md., for the past 4½ yr., on August 1 will join the engineering staff of the Industrial Rayon Corp., Cleveland and New York, with headquarters for the present time at Cleveland, Ohio.

W. O. RANKIN, a pioneer in the application of pulverized fuel to industrial furnaces and for 15 yr. a worker in that field, has been appointed manager of the Industrial Furnace department of Combustion Engineering Corp.

THE UNDERWOOD-ELLIOTT FISHER CO., Hartford, Conn., has taken out a permit for its proposed new power plant estimated to cost $300,000. Plans have been completed by Lockwood, Greene & Co., 24 Federal Street, Boston, architects and engineers.

ANNOUNCEMENT is made that Erie City Iron Works, Erie City, Pa., has built a 1/12 scale model of its Erie City steam unit at the request of the Smithsonian Institution and that it has been accepted for permanent display in its division of Mechanical Technology in the Arts and Industries Bldg. at Washington, D. C. The model, built in the pattern shop, shows the application of the Erie City Seymour water cooled furnace to the Erie City three-drum boiler with integral economizer and fired by the Erie City unitype pulverizer.

NORTHERN EQUIPMENT CO., Erie, Pa., has appointed Don Allshouse as advertising manager. Mr. Allshouse comes to the organization from Lamport, MacDonald Co., advertising agency of South Bend, Ind. Prior to that, he was a member of the department of publicity of the Westinghouse Electric & Manufacturing Co.

TAMPA UNION TERMINAL CO., 823 South Orleans St., Tampa, Fla., Clyde Perry, president, has approved plans for the construction of a new cold storage and precooling plant on 10-acre tract of land on the Ybor Channel. The unit will be eight-story, 150 by 152 ft., and will be used primarily for citrus fruit service. On adjoining site, a one-story power plant, 50 by 80 ft., will be built as well as one-story packing house, 135 by 280 ft. Plans include, also, a two-story transit shed, 100 by 464 ft., for refrigerator cars. Entire project is reported to cost more than $500,000 with equipment. Parsons, Klapp, Brinckerhoff & Douglas, 84 Pine Street, New York, are engineers in charge.

DES MOINES, IOWA, CITY RAILWAY CO. will be sold early in September as result of an order signed by Judge Martin J. Wade in the federal court in Des Moines recently, when Clyde L. Herring and F. C. Chambers, receivers, were unable to make a payment of $1,759,152.02 upon debts due. The court appointed E. J. Kelly, special master, with authority to proceed "without valuation, appraisement, redemption or extension." The receivers' report showed only $118,000 on hand to meet the obligations.

PUBLIC SERVICE CO. OF NEW HAMPSHIRE, Manchester, N. H., has concluded negotiations for the purchase of the Salmon Falls Mfg. Co., Salmon Falls, N. H., operating a local cotton mill, and will take over and run the plant for increased service in that section; it is understood that extensions and improvements will be made, including transmission line construction. The purchasing company has also made application for permission to acquire the Franklin Light & Power Co., with power plant and system at Franklin, N. H., and vicinity and will expand facilities in that district. The company likewise will take title to the Tilton Electric Light & Power Co., Tilton, N. H.

AUTOMATIC ELECTRIC SUB-STATION with 500-kw. mercury arc rectifier to supply trolley wires is being installed at Lemont, Ill., by the Chicago and Joliet Electric Railway Co., replacing equipment which has been in use there since 1901. It will eliminate maintenance service upon two transmission lines between Joliet and Summit. The Public Service company does not generate direct current and the Chicago & Joliet purchases a 33,000-v. alternating current supply from it, transforming it to 985 v. and rectifying it to 600 v.

ROCKFORD, ILL., ELECTRIC CO. has been granted authority by the Illinois commerce commission to purchase the Rockford Public Service Co., including all its properties and franchises, free of lien, except that the Rockford Electric shall assume outstanding bonded indebtedness of the Public Service to the amount of $1,000,000 first mortgage bonds and for the additional consideration of 15,000 shares of common capital stock and $500,000 par amount of 6 per cent preferred capital stock. Authority to operate includes street railway and bus systems and power transmission line throughout the territory formerly served by the Public Service Co. The new company is authorized to issue and sell 165,000 shares of common capital stock, no par value, and $500,000 aggregate 6 per cent preferred capital stock.

CLEVELAND ELECTRIC ILLUMINATING CO., Cleveland, Ohio, has purchased the municipal electric light and power plant at Ashtabula, Ohio, on a bid of $2,356,000. With this acquisition, the Cleveland company will practically control the distribution of light and power in the northeastern section of the state. Work has been started on a new 132,000-v. transmission line from its station at Avon to different points, and the Ashtabula plant will be connected with this line, which will terminate at the Saybrook, Ohio, plant of the utility. Another transmission line is also planned for power service in the Ashtabula dock district. The acquired plant is at present connected with the Lake Shore generating plant of the company by a 33,000-v. power line.

DUKE POWER CO., Charlotte, N. C., affiliated with the Southern Public Utilities Co., has concluded negotiations for the purchase of the Caldwell Power Co. and the County Service Co., operating in the vicinity of Lenoir, as well as the Catawba Valley Light & Power Co. and the Burke Utilities Co. The purchasing company has work under way on a new steam-operated electric generating plant on the Catawba River, at a place known as River Bend, near Mount Holly, N. C., approximately 12 miles from Charlotte, and proposes to have this station ready for service at an early date. It will be equipped to burn pulverized fuel and will have an initial rating of 150,000 hp.

CENTRAL MAINE POWER CO., Augusta, Me., operated by the New England Public Service Co., has authorized plans for a new hydroelectric power development on the upper Kennebec River, near Bingham, Me. The project will include the construction of a 90-ft. power dam to impound approximately 5,000,000,000 cu. ft. of water, with installation of power plant with initial output of 60,000 hp. Transmission lines will be constructed including power switching station facilities. Entire enterprise is scheduled for completion in from 30 to 36 months and is reported to cost more than $7,000,000. George S. Williams is vice president and general manager.

THE MOUNTAIN STATES POWER CO., Tacoma, Wash., a subsidiary of the Standard Gas & Electric Co., Chicago, Ill., has authorized extensions in its hydroelec-

tric generating plant at Big Fork near Kalispell, Mont., including a new 1750-kw. generating unit and auxiliary.

CHARLES C. MOORE & Co., San Francisco, Calif., engineers, have contracted with the British Columbia Electric Railway Co., Vancouver, B. C., which controls the Vancouver Power Co., for the construction of a steam-operated electric generating plant at Burrard Inlet, to be known as the Hastings steam plant. The station will consist of an initial turbo-generator unit of 20,000-kw. capacity, to be supplemented by three additional prime movers of like type at a later date, providing an ultimate output of 80,000 kw. The work will include the construction of docks, with coal-handling and conveying equipment, bunkers, etc., for receiving and storing coal shipped by water. Construction on first unit will proceed at once and is scheduled for completion about the middle of 1930. The company will make extensions in transmission lines. The entire project will cost close to $2,000,000.

THE NORTHERN New York Utilities, Inc., Watertown, N. Y., will begin work at once on a new hydroelectric plant on the Beaver River near Beaver Lake. The plant will be equipped for a capacity of 12,000 hp.

THE BUREAU OF YARDS AND DOCKS, Navy Department, Washington, D. C., will receive bids (no closing date stated) for power equipment for the plant at the marine barracks, Quantico, Va., including powdered coal equipment, boilers and auxiliaries; also a Diesel generating set as per Specification 5602.

THE BEAUHARNOIS ELECTRIC Co., Beauharnois, Que., has secured permission from the Canadian Government to divert 40,000 cu. ft. of water per second from the St. Lawrence River at the western extremity of the Island of Montreal, for hydroelectric purposes. The company agrees to develop a total of 500,000 hp. by the end of the tenth year from date of grant. Entire development is estimated to cost upward of $25,000,000.

UNITED STATES Civil Service Commission, Washington, D. C., announces open competitive examination for fuel engineer, associate fuel engineer and assistant engineer, applications on which must be on file with the Commission not later than September 5. Entrance salaries are $3800 a year, $3200 a year and $2600 a year respectively. Examination is to fill vacancies at the Bureau of Mines and the duties are to conduct under general direction laboratory and field fuel investigations and of boilers and auxiliary investigations of various combustion problems. Full information may be obtained from the Commission or at the postoffice or custom house in any city.

Books and Catalogs

MECHANICS FOR ENGINEERS by Julian C. Smalwood and Frank W. Kouwenhoven. D. Van Nostrand Co., 8 Warren St., New York; 185 pages, 204 illustrations; 6 by 9 in., cloth, $2.50.

Arrangement and selection of material with problems to emphasize the text are the features which the authors have sought to embody. It is designed as a text-book on the subject and leads from definitions and the easier principles to more complex and difficult applications.

No book on this subject is light summer reading and a good knowledge of mathematics, including calculus, is necessary to its study. With this basis assumed, the student is given an understanding of fixed and moving forces, resultant of forces, stresses in framed structures, friction, acceleration and velocity, inertia, rectilinear, rotary and combined motions, work, energy and power.

One logical feature is the establishment for the entire book of a Table of Notation so that the symbols throughout mean the same quantities. Argument and demonstration is clear. The treatment is concise and problems are well chosen.

QUARTERLY BULLETIN No. 18, Volume 5, of the Institution of Engineers of Australia, recently issued by that organization, contains a complete account of the Sixth Engineering Conference of the Institution held in Canberra, the Federal capitol of the Commonwealth of Australia, February 4 to 11, 1928. The headquarters of the Institution are at Macleay House, 16 College St., Sydney, N. S. W.

DRAINS AND TRAPS for floors, showers, swimming pools and the like, together with interceptors, shock absorbers for pipe lines, water heaters and all types of fittings and valves are described in Catalog G, issued by The Josam Mfg. Co., 4900 Euclid Bldg., Cleveland, Ohio. The catalog contains 74 well-illustrated pages and, besides data on the products of the company, many tables of engineering information are given, with dimension drawings of the equipment to be used in design work.

OXWELDED industrial piping is described and clearly illustrated in a 12-page bulletin just issued by the Linde Air Products Co., 30 E. 42nd St., New York City. Copies will be sent to those interested upon request.

CONSTRUCTION DETAILS of interest to those designing outdoor substations are given in an article on Outdoor Substation Design, by H. Lanzl, published in The Delta Star of July 15, sent out by Delta Star Electric Co., Fulton St., Chicago, Ill.

"CORRECT HEATING of Buildings" is the title of an 8-page booklet recently sent out by Webster Tallmadge & Co., Inc., 50 Church St., New York, N. Y.

OUTDOOR RECREATION for employes is discussed in Report No. 76 of the Policyholders Service Bureau, Metropolitan Life Insurance Co., New York, N. Y.

WAGNER BEARING construction, including the Wagner improved sleeve bearing and the Wagner ball bearing, is discussed in detail in bulletin 156 by Wagner Electric Corp., 64th and Plymouth Ave., St. Louis, Mo.

CAMERON MULTI-STAGE centrifugal pumps designed for modern high pressure boiler feeding, hydraulic service in steel mills, mine drainage and the like, are described and attractively illustrated in a 32-page bulletin just issued by Ingersoll-Rand Co., 11 Broadway, New York City.

VARIOUS USES of drag scrapers for handling sand, gravel, coal and other bulk materials are discussed in several articles in Sauerman News for June, 1928, published by Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

Power Plant Construction News

Ala., Mobile—The Fulton Ice Co., Mobile, plans construction of one-story ice-manufacturing plant on the Fulton Road reported to cost more than $45,000.

Calif., Los Angeles—The Kittinger Co., 1893 Elmwood Avenue, Buffalo, N. Y., will install power equipment in a proposed manufacturing plant on Industrial Avenue, Los Angeles, to cost close to $1,000,000. Herbert C. Emmons, 1110 South Oakland Street, Pasadena, Calif., is local representative.

Calif., Richvale—The Pacific Coast Pulp & Paper Co., care of D. M. Thomas, Santa Monica, Calif. (recently organized by Mr. Thomas and associates, with capital of $1,500,000.) will build a one-story boiler plant, 50 x 80 ft., with 150-ft. high stack, at its proposed pulp and paper mill at Richvale, and will install power equipment throughout mill. Entire project will cost more than $800,000.

Colo., Denver—The American Can Co., 120 Broadway, New York, plans installation of power equipment in proposed new plant at Denver to cost more than $500,000; a boiler house is projected.

Conn., New Britain—The Common Council has authorized a bond issue of $1,250,000, proceeds to be used for installation of a filtration plant for municipal waterworks, and extensions in water system, including pumping equipment and accessories. Plans will soon be drawn.

Del., Wilmington—The Board of Water Commissioners, Wilmington, plans the construction of a large central pumping plant on the Brandywine River, in connection with proposed extensions and improvements in the municipal waterworks. A fund of about $3,000,000, will be arranged for entire project.

Fla., Pensacola—The Beebe Ice Co., South Grandview Avenue, Daytona Beach, Fla., has plans for a one-story ice-manufacturing plant at Pensacola, to be equipped for a capacity of about 40 tons per day, estimated to cost approximately $80,000.

Ga., Darien—The Mutual Light & Water Co., Brunswick, Ga., has concluded arrangements for purchase of municipal electric light and power plant at Darien and plans extensions and improvements, including installation of additional equipment.

Ill., Freeport—The Furst-McNess Co., East Clark Street, plans installation of power equipment in proposed five-story addition to local drug and chemical plant; entire project will cost about $140,000.

Ind., Evansville—The Southern Indiana Gas & Electric Co., Sycamore Street, has approved plans for a new steam-operated electric generating plant on West Ohio Street, reported to cost more than $1,300,000, with machinery.

Kan., Wichita—Fred Dold & Sons, Inc., Twenty-first and Lawrence Streets, will install power equipment in a new one-story and basement packing plant, 100 x 180 ft., to cost about $125,000, for which bids will soon be asked on general contract by Henschien & McLaren, 1637 Prairie Avenue, Chicago, Ill., engineers. It is understood that refrigerating equipment will also be installed.

La., Ponchatoula—The Ponchatoula Ice Co., recently acquired by new interests, is considering the construction of a one-story ice-manufacturing and cold storage plant, 100 x 200 ft., reported to cost more than $50,000, with equipment.

Md., Baltimore—The Asiatic Petroleum Co., 65 Broadway, New York, is said to be planning the construction of a boiler house at its proposed oil refining and distributing plant in the Fairfield district, Baltimore, and will install general power equipment for refining service. Entire project will cost in excess of $900,000.

Mass., Millbury—The A. D. Windle Co., Howe Avenue, is considering construction of power plant at local woolen mill,

Miss., Biloxi—The Anticich Packing Co., Biloxi, has approved plans for a new one-story ice-manufacturing plant, 45 x 100 ft., to be equipped for a capacity of 40 tons per day, reported to cost close to $70,000, with machinery.

N. C., Tryon—The Feldspar Milling Co., care of H. A. Dunham, 99 Nerrimon Avenue, Asheville, N. C., plans installation of power equipment in a new feldspar milling plant near Tryon to cost in excess of $75,000. Company was formed recently by Mr. Dunham and associates.

N. J., Trenton—The W. & J. Sloane Mfg. Co., Fifth Avenue and Forty-seventh Street, New York, will install power equipment in proposed addition to its linoleum manufacturing plant at Hutchinson's Mills, near Trenton, to cost more than $500,000. Lockwood, Greene & Co., 1 Pershing Square, New York, are architects and engineers.

N. Y., Lockport—The Palace Laundry Co., Tenth Street, Niagara Falls, N. Y., has filed plans for a two-story steam power house, 46 x 57 ft., reported to cost about $50,000, with equipment.

N. Y., Lyons Falls—The Gould Paper Co., Lyons Falls, plans installation of power equipment in connection with proposed rebuilding of portion of mill at Gouldtown, near Lyons Falls, destroyed by fire, July 20, with loss reported at close to $100,000.

Ohio, Cleveland—The Cleveland Railway Harbor Co., Williamson Building, will install power equipment in proposed eight-story terminal building at the foot of East Fifty-fifth Street to cost more than $10,000,000. Moores & Dunford, Inc., 110 East Forty-second Street, New York, is engineer.

Ohio, Philo—The Electric Pig Iron Corporation, Canton, Ohio, has authorized the immediate erection of an electric-operated ferro-silicon plant near Philo, estimated to cost about $100,000, with machinery. Service will be furnished by the Ohio Power Co.

Okla., Chickasha—The City Council is considering the installation of pumping equipment and auxiliary equipment in connection with proposed extensions and improvements in the municipal waterworks to cost about $350,000. A bond issue is being arranged in amount noted.

Ore., Lebanon—The Oregon Canning Co. plans installation of power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, July 24, with loss reported at more than $200,000.

Pa., Bridgeville—The Mayer Aircraft Co., Bridgeville, C. P. Mayer, president, plans installation of power equipment in a proposed new airplane manufacturing plant, entire project reported to cost in excess of $80,000.

Pa., Philadelphia—The West Philadelphia Stock Yards Co., Thirtieth Street, plans installation of power equipment in a proposed abattoir on Thirty-sixth Street reported to cost more than $750,000. J. N. Harlan is president.

Pa., West Pen Argyl—The Diamond Slate Co., West Pen Argyl, is planning the installation of boilers and auxiliary equipment at its local quarries.

Tenn., Knoxville—The Standard Ice Co., Knoxville, is reported planning construction of new one-story ice-manufacturing plant to cost about $150,000.

Texas, Austin—The Board of Trustees, University of Texas, Austin, will install power equipment in a new chemistry building at the institution, for which a fund of about $800,000, has been arranged. Herbert M. Greene, Laroche & Dahl, Dallas, Texas, are architects.

Texas, Big Springs—Cosden & Co., Fort Worth, Texas, oil refiners, will install power equipment in a new refining plant to be built at Big Springs, estimated to cost in excess of $400,000.

Va., Farmville—The Farmville Furniture & Cabinet Co. plans installation of power equipment in a new factory unit to cost about $90,000. Monroe Johns is president.

Wash., Omak—The Biles-Coleman Lumber Co., Omak, plans installation of power equipment in a proposed one-story mill addition reported to cost about $100,000.

W. Va., Benwood—The Pennsylvania Railroad Co., Pittsburgh, Pa., will install power equipment in proposed engine house and locomotive repair works at Benwood, entire project to cost close to $200,000.

Wis., Horicon—The Van Brunt Mfg. Co., a subsidiary of the John Deere Plow Co., Moline, Ill., will install power equipment in new addition to local agricultural implement plant reported to cost more than $90,000.

Wis., Milwaukee—The Geuder, Paeschke & Frey Co., Fifteenth Street, plans installation of power equipment in new addition to enamelware plant reported to cost close to $100,000, with equipment.